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VOLUME IV

THE BROSS LECTURES . . 1907

THE BIBLE OF NATURE

FIVE LECTURES DELIVERED BEFORE
LAKE FOREST COLLEGE
ON THE FOUNDATION OF THE LATE
WILLIAM BROSS

BY

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THE BROSS FOUNDATION

THE Bross Lectures are an outgrowth of a fund established in 1879 by the late William Bross, Lieutenant-Governor of Illinois from 1866 to 1870. Desiring some memorial of his son, Nathaniel Bross, who died in 1856, Mr. Bross entered into an agreement with the "Trustees of Lake Forest University," whereby there was finally transferred to them the sum of forty thousand dollars, the income of which was to accumulate in perpetuity for successive periods of ten years, the accumulations of one decade to be spent in the following decade, for the purpose of stimulating the best books or treatises "*on the connection, relation and mutual bearing of any practical science, the history of our race, or the facts in any department of knowledge, with and upon the Christian Religion.*" The object of the donor was to "*call out the best efforts of the highest talent and the ripest scholarship of the world to illustrate from science, or from any department of knowledge, and to demonstrate the divine origin and the authority of the Christian Scriptures; and, further, to show how both science and revelation coincide and prove the existence, the providence, or any or all of the attri-*

butes of the only living and true God, 'infinite, eternal and unchangeable in His being, wisdom, power, holiness, justice, goodness, and truth.'"

The gift contemplated in the original agreement of 1879 was finally consummated in 1890. The first decade of the accumulation of interest having closed in 1900, the Trustees of the Bross Fund began at this time to carry out the provisions of the deed of gift. It was determined to give the general title of "The Bross Library" to the series of books purchased and published with the proceeds of the Bross Fund. In accordance with the express wish of the donor, that the "Evidences of Christianity" of his "very dear friend and teacher, Mark Hopkins, D.D.," be purchased and "ever numbered and known as No. 1 of the series," the Trustees secured the copyright of this work, which is now numbered as Volume I of the Bross Library.

The trust agreement prescribed two methods by which the production of books and treatises of the nature contemplated by the donor was to be stimulated:

1. The Trustees were empowered to offer one or more prizes during each decade, the competition for which was to be thrown open to "the scientific men, the Christian philosophers and historians of all nations." In accordance with this provision, a prize of $6,000 was offered in

1902 for the best book fulfilling the conditions of the deed of gift, the competing manuscripts to be presented on or before June 1, 1905. The prize was awarded to the Reverend James Orr, D.D., Professor of Apologetics and Systematic Theology in the United Free Church College, Glasgow, for his treatise on "The Problem of the Old Testament," which was published in 1906 as Volume III of the Bross Library. The next decennial prize will be awarded about 1915, and will be announced in due time.

2. The Trustees were also empowered to "select and designate any particular scientific man or Christian philosopher and the subject on which he shall write," and to "agree with him as to the sum he shall receive for the book or treatise to be written." Under this provision the Trustees have, from time to time, invited eminent scholars to deliver courses of lectures before Lake Forest College, such courses to be subsequently published as volumes in the Bross Library. The first course of lectures, on "Obligatory Morality," was delivered in May, 1903, by the Reverend Francis Landey Patton, D.D., LL.D., President of Princeton Theological Seminary. The copyright of these lectures is now the property of the Trustees of the Bross Fund. The second course of lectures, on "The Bible: Its Origin and Nature," was delivered in May, 1904, by the Reverend Marcus

Dods, D.D., Professor of Exegetical Theology in New College, Edinburgh. These lectures were published in 1905 as Volume II of the Bross Library. The third course of lectures, on "The Bible of Nature," was delivered from September 24 to October 3, 1907, by Mr. J. Arthur Thomson, M.A., Regius Professor of Natural History in the University of Aberdeen. These lectures are embodied in the present volume.

JOHN SCHOLTE NOLLEN,

President of Lake Forest College.

LAKE FOREST, ILLINOIS,
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I

THE WONDER OF THE WORLD

I

THE WONDER OF THE WORLD

The Sense of Wonder.—Perhaps even the most "profane person" has some secret shrine where he allows himself at least to *wonder*. What may not the object of this wonder be—the grandeur of the star-strewn sky, the mystery of the mountains, the sea eternally new, the way of the eagle in the air, the meanest flower that blows, the look in a child's eyes? Somewhere, sometime, somehow, every one confesses, "This is too wonderful for me."

The sense of wonder varies in expression according to race and temperament, according to health and habits, according to its degree of culture and freedom. Caliban's is different from Ariel's, and Prospero's from both. But whatever be its particular expression, the sense of wonder is one of the saving graces of life, and he who is without it might as well be dead. It lies at the roots of both science and philosophy, and it has been in all ages one of the footstools of religion. When it dies one of the lights of life goes out. Keeping to the outer world of nature, let us illustrate what may be called the mainsprings of rational wonder.

Abundance of Power.—In ancient days when mastery of the forces of nature was not even dreamed of, men were almost overwhelmed by their sense of the abundance of power in the world. Unable to see much order in this power, unable to utilize it, they took what came and wondered. Often personifying the various forces, they brought thank-offerings when these were benign and sacrifices when they were hostile. Short-sighted and timorous, they paid heavy premiums to experience, and yet were slow to learn. It may be, however, that they excelled us, in whom familiarity has bred commonplaceness, in their keener sense of the abundance of power in the world. It seems sometimes as if we needed an earthquake, a volcanic eruption, a tornado, a comet, to re-awaken us to a sense of the world *δύναμις*, to the powers that make our whole solar system travel in space toward an unknown goal, that keep our earth together and awhirling round the sun, that sway the tides and rule the winds, that mould the dew-drop and build the crystal, that clothe the lily and give us energy for every movement and every thought —in short that keep the whole system of things agoing.

"Trees in their blooming,
Tides in their flowing,
Stars in their circling,
Tremble with song."

And one note in that song is *Power*, which we cannot think of as beginning or as ending, which never seems to alter in quantity though it is always changing its quality, which is not a whit less wonderful though we say that it is "*all electricity*," and certainly not less wonderful if we are able to say

> "God on His throne
> Is Eldest of poets,
> Unto His measures
> Moveth the whole."

A Modern Instance.—Let us take a now familiar instance of this Power. Besides theoretical and possibly practical results, there has been some emotional gain in the recent startling discoveries which centre around the word radio-activity. From a ton of pitch-blende, the investigators extract less than a grain of radium, which, apart from living matter, is the most wonderful kind of matter in the world. Incessantly and without appreciable loss it pours forth heat and light; its rays penetrate thick plates of metal, excite phosphorescence in other bodies, discharge electroscopes from a distance, and have strange effects on living creatures. We are told that radium gives off not only rectilinear darting rays, but also a gaseous emanation which is radio-active, which precipitates itself as a "something" on various kinds of bodies and makes them also radio-active. It decays and be-

comes, in part at least, something else—namely, that rare stuff called Helium, which Sir Norman Lockyer found many years ago in the Sun, which also occurs in warm springs and rare minerals. One kind of radium ray is said to consist of streams of little bodies, which travel at the rate of 20,000 miles a second, 40,000 times faster than a rifle bullet; another kind is said to consist of streams of little bodies, darting forth at the prodigious rate of 100,000 miles a second; another kind is said to consist of pulses in the ether, which can penetrate a foot of solid iron. In spite of all the energy it gives off, radium is but slowly used up. It is possibly being continually formed afresh in the earth, perhaps from Uranium. A small quantity diffused in the earth will suffice to compensate for all the loss of heat by radiation; a fraction of one per cent. in the sun would compensate for all its immense loss of heat. Is *this* not "too wonderful for us?"

Power of Life.—We do not perhaps think much about it, but the abundance of power in living creatures is truly wonderful, just as wonderful as radium. Call them engines—animate systems which transform matter and energy—they are more perfect than our best engines, the perfection being measured by the relation between the energy which enters them and the work they do. "Joule pointed out that not only does an animal much

more nearly resemble in its function an electromagnetic engine than it resembles a steam-engine, but also that it is a much more efficient engine; that is to say, an animal, for the same amount of potential energy of food or fuel supplied to it—call it fuel, to compare it with other engines—gives you a larger amount converted into work than any engine which we can construct physically." Langley pointed out that a fire-fly is a much more economical light-producer than any human luminiferous device. As a physicist looking at life and puzzling over its dynamic mystery, Professor Joly advanced the following interesting and important proposition: "While the transfer of energy into any inanimate material system is attended by effects retardative to the transfer and conducive to dissipation, the transfer of energy into any animate material system is attended by effects conducive to the transfer and retardative of dissipation." From a dynamic point of view it is wonderful to watch, let us say, a few water-mites imprisoned in a vessel where the supply of food is of the smallest. Day after day, week after week, we see them darting about with extreme rapidity, we hardly ever catch them napping. They cannot evade the law of the conservation of energy, but it certainly seems as if they did.

Or take another entirely different case—the destructive power of microbes. It seems certain

that some microbes in certain phases can pass through the most carefully constructed water-filter and are invisible to the best microscope. We know that they pass through by the results; we can get cultures of them out of the water. Yet these invisibly minute creatures have so much constructive power that from one, in a few hours, a million may result, and so much destructive power that a small dose of them soon kills an ox.

Abundance of Life.—We need only allude to the actual abundance of life. The roll-call of animals includes so many tens of thousands of species that, so far as our power of realizing the total is concerned, it is hardly affected when we note that more than half of them are insects. More than two thousand years ago Aristotle recorded a total of about 500 animals, but there may be more new species in a single volume of the *Challenger* Reports. We speak of the number of stars, yet more than one family of insects is credited with including as many different species as there are stars to count with the unaided eye on a clear night. And besides the number of different kinds, think of the uncountable numbers of individuals.

> "But what an endlesse worke have I on hand
> To count the sea's abundant progeny
> Whose fruitful seede farre passeth those on land,
> And also those which wonne in th' azure sky,
> How much more eath to tell the starres on hy,

Albe they endlesse seem in estimation,
Than to recount the sea's posterity,
So fertile be the floods in generation,
So huge their numbers and so numberless their nation."

The explorers of the Antarctic seas tell us that from these cold waters it was quite the usual thing to take from ten to thirty thousand specimens of a certain crustacean in a single haul. In short, the naturalist as well as the poet spoke when Goethe celebrated Nature's wealth: "In floods of life, in a storm of activity, she moves and works above and beneath, working and weaving, an endless motion, birth and death, an infinite ocean, a changeful web, a glowing life; she plies at the roaring loom of time and weaves a living garment for God."

Immensities.—The simple and open mind is always impressed by the bigness of Nature. Our ancestors were thrilled by the apparently boundless and unfathomable sea, by the apparently unending plains, by the mountains whose tops were lost in the clouds, by the expanse of the heavens; and our children happily have still something of the same impression of the wide, wide world. It is the impression of immensity—of practical infinitude, and it is worth having and keeping. Nowadays, of course, we measure everything, and the wonder tends to fade. Every day we get some fresh instance of the way in which "Science reaches forth her arms to feel from world to world, and

charms her secret from the latest moon." We annihilate distance with our deep devices and make the ether carry our signals. We bring the moon so near that our maps of it are better than those of Africa three generations ago. We measure the distance of the stars; we analyze the chemical composition of the sun. It is enough to recall Fraunhofer's fine epitaph, "Approximavit sidera."

Thus size and distance are ceasing to impress us as they impressed our forefathers. We are becoming accustomed to the immensities. Yet we do well to sit down quietly at times under the starry heavens, and remember that though light travels 186,000 miles a second, we might perchance observe the twinkling of a star that had gone out; that when we look at *a* Centauri, which lies some ten billions of miles nearer to us than any other known star, we see it, not as it is to-night, but as it was more than four years ago; that, though our sun is 93,000,000 of miles away (and no one of us has any mental picture of what a million is), the farthest star we can see is a million times farther off; that for every one of the few thousands (say 8,000) of stars we can see with our unaided eyes there are thousands unseen (say, a hundred millions); and that our whole solar system is equivalent in size to no more than a corner of the Milky Way. In the heavens the navigator sails in a

practically infinite ocean; for leagues and leagues beyond there is always more sea. There is room for wonder.

Manifoldness.—Another primary impression of Nature is that of manifoldness. Star differs from star in glory. Every mountain has its individuality. There are over eighty different kinds of elements. The number of different minerals is legion. "All flesh is not the same flesh, but there is one flesh of men, another flesh of beasts, another of fishes, and another of birds." From one small island (Great Britain) we have a record of over four hundred different kinds of birds, each a very distinctive personality. In the *Challenger* Report on Radiolarians, Haeckel deals with about five thousand different species, all of fascinating beauty. A single year's volume of the *Zoological Record* may register more new species than were included in the whole of Linné's "Systema Naturae." Whether we gather shells on the shore or collect snow crystals; whether we study birds or brambles, hydroids or hawkweeds, we get the same impression of an overflowing form-fountain, of prodigal multiplicity, of endless resources.

Intricacy.—An allied impression, unknown to the ancients, is that of intricacy. The telescope reveals a hundred million heavenly bodies; the microscope reveals another unseen world of the infinitely

small, each member of which is nevertheless intricate. One of President D. S. Jordan's epigrams is unforgetable, "The simplest organism we know is far more complex than the Constitution of the United States." The body of an ant is many times more visibly intricate than a steam engine; its brain, as Darwin said, is perhaps the most marvellous speck of matter in the universe. Our brain is such a labyrinth of nerve paths that it takes years to become even superficially familiar with it. The body of an animal may consist of millions of unit-areas or cells; each shows a complex foam-like or net-like living matter, including a nucleus which is a microcosm in itself. Within each nucleus there are stainable bodies or chromosomes, twenty-four of them in each of our body-cells, and these are built up of smaller microsomes, and each chromosome is split longitudinally when the cell divides. And when we pass beyond the visibly intricate, to the coarse-grainedness which the physicists find it necessary to postulate in matter, the intricacy is multiplied beyond all our powers of picturing. They say that in a tiny organism no larger than a minute-hand on a dainty watch there is a molecular intricacy which might be represented by an Atlantic liner packed with such watches. Some say that the simplest of all atoms—an atom of hydrogen—must have a constitution as complex as a constellation, with about

800 separate parts. Here again there is room for some rational wonder.

Pervading Order.—In spite of all this multiplicity and intricacy, there is a pervading order. The world is not a curiosity shop, but a Kosmos. There do not seem to be many big collisions in the crowded heavens, and there is no hint of fortuity. The clockwork goes so steadily that the return of a comet can be predicted to a night. There have been cataclysms in the history of the Earth, but they are not more disorderly than the cracking of the sun-baked clay. There is order in the relations of the atomic weights of the chemical elements (Mendeleeff's "Periodic Law"), just as there is order in the relations of the planets. The wind bloweth where it listeth, and yet we know, as Tyndall said, that "the Italian wind, gliding over the crest of the Matterhorn, is as firmly ruled as the earth in its orbital revolution round the sun; and the fall of its vapour into clouds is exactly as much a matter of necessity as the return of the seasons."[1] Our body is a most intricate engine, yet how smoothly it works if we give it a chance. Creatures living naturally may have parasites, but they hardly ever show any disease. That comes when man tampers with them or with their surroundings. Natural death is a most orderly phenomenon. And even the disorders which man

[1] "Fragments of Science."

brings about, are, as statistics show, appallingly orderly in their occurrence. In short, it is not a multiverse we live in, but a universe. It is not "all weather."

We cannot deny that there are occurrences which give us pause in our assertion of pervading order—but most of these are within the human realm, and many of them are by no means inevitable. Man is extraordinarly callous in the way of taking risks, and perhaps the terrible tragedy of much in human life is needed as a spur to incite us to put an end to it. Most people profess to be shocked at the wastage of life, often very indiscriminate, involved in many microbic diseases or in war, and yet the bulk of us do not really care so very much—till the wolves attack our own flocks. If we did care enough, we should soon put a stop to both infectious diseases and war. A great authority has said that "all epidemic disease could be abolished in fifty years." Perhaps this is too sanguine, perhaps the expert underestimated the *social* cost of the riddance, but in any case the declaration cannot be left out of consideration. It does not take very long to rid a country of rabies. Why not of other forms of madness?

Network of Interrelations.—It is part of this order that the world is a network of interrelations. Part is linked to part by sure, though often subtle,

bonds, and nude isolation is as rare in nature as a vacuum. Nature is a vast system of linkages. Every one knows how Darwin, by showing that earthworms have made most of the fertile soil of the world, verified in detail what Gilbert White had foreseen in 1777: "The most insignificant insects and reptiles are of much more consequence and have much more influence in the economy of nature than the incurious are aware of. . . . Earthworms, though in appearance a small and despicable link in the chain of Nature, yet, if lost, would make a lamentable chasm." What we may call "nutritive chains" connect many forms of life—higher animals feeding upon lower through long series, the records of which read like the story of "The House that Jack Built." The flowering plants and the higher insects have grown up throughout long ages together, in alternate influence and mutual perfecting. Every one knows Darwin's "cats and clover" story, and it is but a type. It was Darwin also who removed a ball of mud from the foot of a bird, and found that fourscore seeds germinated from it. Not a bird can fall to the ground without sending a throb through a wide circle. We can follow the circulation of matter from the mud by the pond-side till it becomes part of the physical basis of clear thinking. We can connect the lady's toilet-table with the African slave-trade, or the demand for

well-burnished bicycles with the extermination of the walrus. As Shelley wrote:

> "Nothing in this world is single;
> All things by a law Divine
> In each other's being mingle!"

Only the working naturalist knows the extent to which living creatures are interlinked in nature. There is a solidarity of kinship, but there is also a solidarity of vital relations. We are familiar with the correlation of organs in the living body, but there is also a correlation of organisms in the web of life. The young of the fresh-water mussel must be nurtured for a time as hangers-on to fishes; there is a fresh-water fish (the bitterling, *Rhodeus amarus*) whose young must be nurtured for a while inside the gills of the mussel. And this is but an instance among thousands. We recall a remarkable passage of Locke's: "This is certain, things, however absolute and entire they seem in themselves, are but retainers to other parts of nature, for that which they are most taken notice of by us. Their observable qualities, actions, and powers are owing to something without them; and there is not so complete and perfect a part that we know of nature, which does not owe the being it has and the excellence of it to its neighbors; and we must not confine our thoughts within the surface of any body, but look a great

deal farther, to comprehend perfectly those qualities that are in it."

Over a ploughed field in the summer morning we see the spider-webs in thousands, glistening with dew-drops, and this is an emblem of the intricacy of the threads in the web of life—to be seen more and more as our eyes grow clear. Or, is not the face of nature like the surface of a gentle stream, where hundreds of dimpling circles touch and influence one another in an intricate complexity of action and reaction beyond the ken of the wisest?

Universal Flux.—Another aspect of the world, which cannot be clearly thought of without a feeling of wonder, was expressed in the old saying of Heraclitus: *πάντα ῥεῖ*, all things are in flux. The rain falls; the springs are fed; the streams are filled and flow to the sea; the mist rises from the deep and the clouds are formed, which break again on the mountain-side. The plant captures air, water, and salts, and with the sun's aid, builds them up by vital alchemy into complex substances, incorporating these into itself. The animal eats the plant and a new incarnation begins. All flesh is grass. The animal beccmes part of another animal, and the reincarnation continues. The living thing dies and returns to the earth, the bundle of life all broken. The microbes of decay break down the dead, and there is a return to air

and water and salts. Nothing is lost, but nothing is permanent. All things flow. As Huxley said: "Natural knowledge tends more and more to the conclusion that 'all the choir of heaven and furniture of the earth' are the transitory forms of parcels of cosmic substance wending along the road of evolution, from nebulous potentiality, through endless growths of sun and planet and satellite; through all varieties of matter; through infinite diversities of life and thought; possibly, through modes of being of which we neither have a conception, nor are competent to form any, back to the undefinable latency from which they arose. Thus the most obvious attribute of the cosmos is its impermanence. It assumes the aspect not so much of a permanent entity as of a changeful process, in which nought endures save the flow of energy, and the rational order which pervades it."

It may be permissible to quote, from Dr. J. Theodor Merz, Rückert's beautiful poem, "Chidher," as a fine expression of the cyclic conception of existence:

> "Chidher, the ever youthful, spake:
> I passed a city on my way,
> A man in a garden fruit did break,
> I asked how long the town here lay?
> He spoke, and broke on as before,
> 'The town stands ever on this shore,
> And will thus stand forevermore.'

"And when five hundred years were gone
I came the same road as anon;
Then not a mark of town I met.
A shepherd on the flute did play,
The cattle leaf and foliage ate.
I asked how long is the town away?
He spake, and piped on as before,
'One plant is green when the other's o'er,
This is my pasture forevermore.'

"And when five hundred years were gone
I came the same road as anon,
Then did I find with waves a lake,
A man the net cast in the bay,
And when he paused from his heavy take,
I asked since when the lake here lay?
He spake, and laughed my question o'er,
'As long as the waves break as of yore,
One fishes and fishes on this shore.'

"And when five hundred years were gone
I came the same way as anon.
A wooded place I then did see,
And a hermit in a cell did stay;
He felled with an axe a mighty tree.
I asked since when the wood here lay?
He spake: 'The wood's a shelter forevermore
I ever lived upon this floor,
And the trees will grow on as before.'

"And when five hundred years were gone
I came the same way as anon,
But then I found a city filled
With market's clamour shrill and gay.
I asked how long is the city built,

Where's wood and sea and shepherd's play?
They pondered not my question o'er,
But cried: 'So was it long before,
And will go on forevermore.'
And when five hundred years are gone
I'll go the same way as anon." [1]

Persistence amid Change.—But in spite of all this ceaseless flux there is steadiness and persistence. The most familiar instance is the living body, which is continually changing—in whirlpool-like fashion—and yet remains very much the same year in, year out. From one point of view vital activity is in great part a process of combustion —often very intense—yet not less remarkable than the ceaseless change is the retention of integrity.

[1] Quoted from J. T. Merz's "History of European Thought in the Nineteenth Century," Vol. II, p. 289.

Goethe summed up the Heraclitian doctrine of universal flux in his well-known poem "Eins und Alles."

"Und umzuschaffen das Geschaffne,
Damit sich's nicht zum Starren waffne,
Wirkt ewiges, lebendiges Thun.
Und was nicht war, nun will es werden,
Zu reinen Sonnen, farbigen Erden,
In keinem Falle darf es ruhn.

Es soll sich regen, schaffend handeln,
Erst sich gestalten, dann verwandeln,
Nur scheinbar steht's Momente still,
Das Ewige regt sich fort in allen;
Denn alles muss in Nichts zerfallen,
Wenn es im Sein beharren will."

So, on a larger scale, we see in racial evolution the twofold aspect of flux and continuity, of change and persistence, of deviation and inertia, of variation and hereditary resemblance. *Alle Gestalten sind ähnlich, und keine gleichet der andern.* Huxley put the point with his usual vividness: "Flowers are the primers of the morphologist; those who run may read in them uniformity of type amidst endless diversity, singleness of plan with complex multiplicity of detail. As a musician might say: every natural group of flowering plants is a sort of visible fugue wandering about a central theme which is never forsaken, however it may, momentarily, cease to be apparent." ("Life of Owen," Vol. II, p. 288.)

In the relatively small group of Alcyonarian corals, with which we happen to be particularly familiar, the general plan of structure is exceedingly simple—polyps give off stolons from which other polyps arise and the colony is supported by some sort of skeleton—but the heterogeneity of detail and of beautiful architectural device beggars description.

Even within the same species we can often get the same impression of "a sort of visible fugue wandering about a central theme." Take, for instance, the beautiful series of three dozen or so distinct varieties of the common snail, *Helix alternata*, say, as they are displayed in the American Museum of Natural History. As Mr. Fran-

cis Galton puts it: "The organic world as a whole is a perpetual flux of changing types." And yet there is a not less remarkable stability of types, and the great styles of organic architecture are after all very few.

The Drama of Animal Life.—To the naturalist there is perennial wonder in the drama of animal life. The more he knows of animal behavior, the greater is his wonder. Let us think of this for a moment.

All around us, except in our cities, we see a busy animal life, swayed by the twin impulses of Hunger and Love. There is eager endeavour after individual well-being, there is not less careful effort which secures the welfare of the young. The former varies from a keen and literal struggle for subsistence to a gay pursuit of æsthetic luxuries; the latter rises from physiologically necessary life-losing and instinctive parental industry to remarkable heights of what seem to us like deliberate sacrifice and affectionate devotion. The old question and answer are fundamental, for beast as well as man:

> "Warum treibt sich das Volk so und schreit?
> Es will sich ernähren, Kinder zeugen,
> Und die nähren so gut es vermag."

On the one hand, we see struggle,—struggle between mates, between rival suitors, between

nearly related fellows, between foes of entirely diverse nature, between the powers of life and the merciless forces of the inorganic world.

On the other hand, we see the love of mates, family affection, mutual aid among kindred, many quaint partnerships and strange friendships, and intricate interrelations implying at least some measure of mutual yielding.

On the one hand, as in a human society or in the single body, we see a regulated system, the harmonious working of correlated parts, mutual adjustments, and the subordination of the individual to the whole. On the other hand, we see struggle, friction, anarchy, the natural self-assertiveness of the individual or of the individual part rising against the limitations imposed by environing circumstances.

We watch the wondrous industry of birds and bees who work from the dawn until the dusk brings enforced rest to their brains, which we know to suffer fatigue as ours do; on the other hand, we see the parasite's drifting life of ease. Here locust eats locust, and rat eats rat; there, in the combat of stags, lover fights with lover till death conquers both; there, again, a mother animal loses her life in seeking to save her children. At one pole we see simple, brainless creatures pursuing their daily life with what we can hardly call more than dull sentience; at a higher

level we marvel at an instinctive skill whose expression is unconscious art; finally, we are face to face with an intelligent behavior which seems at once a caricature and prototype of our own conduct.

Let us recall, for a moment, just one of the wonders of animal behavior—the wonder of migration. There is the migration of those birds that "know no winter in their year," "wild birds that change their season in the night, and wail their way from cloud to cloud down the long wind." What journeys they take—the Arctic Tern was found by the "Scotia" explorers in the Far South! How swiftly they fly, how confidently across the pathless sea, at night, at a great altitude. How strange that the young birds usually fly away first in the autumn, without waiting for those who have made the journey before. How striking the fact—proved for some birds—that they may return from their winter-quarters to the garden where they spent the summer.

Or take as another instance of migration the life-history of the common European eel. It begins its life below the 500 fathom line on the floor of the deep sea—in that dark, cold, calm, silent, plantless world; it passes to the surface as a flattened, transparent larva and lives an open-sea life for over a year, not eating anything, and growing rather smaller as it grows older; it becomes a

young eel or elver which makes for the shore and proceeds up the rivers. In spring or early summer legions of these elvers pass up stream, obedient to their instinct to go right ahead as long as the light lasts. Before reaching such rivers as those which flow into the Eastern Baltic, the young eels have had a journey of some 3,000 miles, for all the North European eels seem to have their cradle in the Atlantic west of the Faroes, the Hebrides, Ireland and Spain, where the continental plateau shelves steeply down into the greater depths. As the elvers pass up the streams there is, according to some, a separation of the sexes; the males lag behind; the females go further inland. Then follows a long period of growth in slow-flowing reaches of the rivers and in ponds. After some years there is a return journey to the sea, and, as far as we know, the individual life ends in giving origin to new lives. There is never any breeding in fresh water, and there seems to be no return from the deep sea.

Adaptations.—One of the most characteristic features of the animate world is the all-pervading fitness. It was Romanes who said, "Wherever we tap organic Nature, it seems to flow with purpose." We may differ as to our interpretation, but the fitness of living creatures as regards structure and habits and interrelations is a *fact*. How well the structure of bone is suited to stand strains, how

well the bird's skeletal and muscular systems are adapted for flight, how well the heart is constructed for its ceaseless work, what a fine instrument the eye is, how readily the leaf insects escape detection when they alight on a branch, how effective a contrivance is the Venus Fly-trap! But so one might go on for hours.

To our forefathers, who were dominated by a static view of the world, the subtle special fitnesses seen throughout Nature, afforded direct evidence of the immediate action of a Divine artificer. We do not hold that view now, partly because it is rather a crude view, mainly because our view of Nature is no longer static but kinetic. Even when the kinetic view was taken, it seemed to some that Nature was like a troublesome child, always getting into scrapes and tight places so that the author of its being might show His skill in extricating it by beautiful contrivance. But we can give a plausible history of many of these adaptations, we find them in varied stages of perfection. Therefore the argument from design has given place to a deeper recognition of rationality. The Order of Nature is such that an increasing evolution of fitness is possible, there is adaptation in cosmic evolution as a whole—it leads up to intelligent, moral persons, adapted to the intellectual and practical conquest of Nature, adapted to mirror the reason without in the reason within. Our fore-

fathers were impressed by the tactics of Nature, we are impressed by the strategy.

"There is a wider teleology," Huxley wrote, "which is not touched by the doctrine of evolution, but is actually based upon the fundamental proposition of evolution."

Progress.—The crowning wonder of the world is that the succession of events spells progress. What we more or less dimly discern in the long past is not like the succession of patterns in a kaleidoscope; it is rather like the sequence of stages in the individual development of a plant or an animal,—stages whose meaning is disclosed more and more fully as the development goes on. It is not a phantasmagoric procession that the history of nature reveals, it is a drama. The solid earth is more differentiated and integrated than a swarm of meteorites; it is in some sense progress to become fit to be a home of life, a home of creatures who can feel and understand, who can sometimes give the earth more significance than it had before. All through the ages we see life slowly creeping upward, with many losses, but with steady gains. Living creatures become nobler, their life becomes fuller and freer, there is an increasing expression of the Psyche, and in man the hitherto voiceless Logos—implicit in the progressive order—becomes at last articulate. As Lotze has said in his "Microcosmus": "The

series of cosmic periods must be a chain, each link of which is bound together with every other in the unity of one plan. . . . As we required that each section of the world's history should present a harmony of the elements firmly knit together, so we must now require that the successive order of these sections shall compose the unity of an onward advancing melody." The unity of an onward advancing melody!

Beauty.—We have not said anything in regard to the beauty of the world, partly because the theme is so difficult, and partly because no small part of the beauty is implied in the order, the intricacy, and the fitness of things. It may be safely said that every finished and normal living thing is beautiful—an artistic harmony when in its natural setting. This suggests the truth of the Platonic conception that a living creature is harmonious because it is the realization of a single idea. The only ugly plants are those which have been deformed or discolored by cultivation. The omnipresence of beauty in finished and normal living things must have some meaning, and even if it only mean that something in us responds pleasurably to what nature mints and fashions, that is a fact of great significance. Beside the remarkable verse in the Book of Wisdom which says: "Thou hast ordered all things in measure and number and weight"—we may rank its correlative,

"He has made all things beautiful in their season."

We lift a tiny shell from the shore, and though we know that it is simply an "exoskeleton,"—a cuticular secretion of part of the mollusc's skin, we find it exquisitely fashioned, "a miracle of design," and we must say the same of every normal finished organic product in every corner of creation.

In regard to the beauty of organic structures, it is perhaps of interest to remember that much of it—much of the best of it—is quite unseen, except by the scientific searcher. Much is covered up by the living tissue, as in the exquisite flinty skeleton of the Venus' Flower-Basket; much is hidden in the darkness of deep waters; much is microscopic. In many cases we can justify the beauty on utilitarian grounds, thus it may be architecturally effective for resisting strain and stress, or it may be protective by harmonizing with surrounding color; in many other cases it seems to us as if it were sheer decoration without significance, except that it expresses the creature that makes it.

Retrospect.—We have tried to illustrate what may be called the basis of rational wonder. We have spoken of the abundance of power, of the immensities, of the manifoldness and intricacy of things, of the order that pervades the whole, of the subtle interrelations in the web of life, of the

changefulness of everything, of the fitness of living creatures, of the progressive trend of things, and of the beauty which is everywhere.

Wonder and Knowledge.—Thinking of these wonders arouses two general reflections. The first of these, we may put in the form of a question. Is any one thing really more wonderful than another? Does it not in great part depend on how much we know about a thing, whether we call it wonderful or not?

We pick up a pebble from the road and throw it carelessly away. The geologist picks it up, and begins to tell us its history, that it is water-worn, though there is no longer any water near, that it is part of a disguised raised beach through which the road has been cut, that it is a piece of jasper which was fused under great pressure millions of years ago, that it must have travelled far, swept down by an ancient river to a now shrunken sea, and so on. Before he has gone far into his story, we are interested, our horizon becomes more distant, and we soon begin to wonder.

We brush aside the common weeds, which we have seen so often that we have almost ceased to see them at all—yellow primroses and nothing more—sometimes, in fact, not so much. But we take time to look at them, and how beautiful they become in our eyes, how intricate, how full of individuality. We take time to study them, with their

parts so perfectly correlated and so well adapted to their surroundings; we learn something of their relationships and long pedigree, discovering, it may be, that their race is much older than our own; we enter the laboratory of the leaf and study the strange alchemy that goes on there, the raising of dead raw materials to the level of livingness; we find that its substances are breaking down and being built up again—a ceaseless combustion, "nec tamen consumebatur"; we watch the plant grow from the invisible to the visible, from one cell to a million of cells, from apparent simplicity to obvious complexity; we see the bee come to visit it, and the quaint give-and-take that occurs; we see the storing up of treasure for a new generation, and that generation being born; we watch the leaf withering and the flower fading, and we often see the return of all but the seeds to the level of the not-living once more. Without being insincere, without being more than awake to the wonder of the commonplace, may we not say:

> "Flower in the crannied wall,
> I pluck you out of the crannies;
> I hold you here, root and all, in my hand
> Little flower—but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is."

We lift aside the earthworm which lay adying on the foot-path, so contemptible that we say "even

a worm will turn." But we pause to think of the part earthworms have played in the history of the earth, and we recognize that they are *the* most useful animals. By their burrowing they loosen the earth, making way for the plant rootlets and the raindrops; by bruising the soil in their gizzard they reduce the mineral particles to more useful form; by burying the surface with stuff brought up from beneath they were ploughers before the plough, and by burying leaves they have made a great part of the vegetable mould over the whole earth. There may be 50,000 or 500,000 of them in an acre; they often pass ten tons of soil per acre per annum through their bodies; and they cover the surface at the rate of three inches in fifteen years. We begin to respect them.

We inquire into their structure—their exquisitely sensitive skin, their highly developed musculature arranged like the hoops and staves of a barrel, their food canal—an object-lesson in division of labor, their red blood—so different from our own, their exquisite kidney-tubes, their tiny brains and their ventral chain of nerve-centres, we go into minutiæ and we find that it will take us many months to work out the details of the nerve-cells or of the complex reproductive system. The more we know, the more the wonder grows.

We study their habits—their long nocturnal peregrinations prompted by "love" and hunger,

their transport of little stones to protect the entrance to the burrows, their deft way of dealing with leaves difficult to manage. We note that though eyeless they are very sensitive to light and persistently avoid it when in good health; that though earless, they are quickly aware even of the light tread of a hungry blackbird; that though they are without anything like a nose, they have a sense of smell—fine instances, in short, of functions before organs. We inquire into their relations with other living creatures, and we find that they have not a few parasites—even worms within worms—to most of which, as is usual among animals, they have so adjusted themselves that nothing detrimental happens, while to one kind at least—the larvæ of a fly—they often succumb. We find that they are persecuted by numerous enemies, such as centipedes, moles, and birds, and we can then better understand their extraordinary power of growing a new tail or even a new head after injury or breakage. We may possibly discover the eerie collection of decapitated earthworms which moles sometimes make as a store of food for winter—decapitated, so that they cannot crawl away and yet remain fresh food, unable even to regrow their heads while they are waiting to be eaten, for the regeneration does not occur at a low temperature. We may inquire into their individual development, now so well known that we could almost make a

kinematograph of the successive stages, and yet in its essence absolutely beyond our understanding. We may ask about the numerous different kinds, some dwarfs, some giants, about their distribution over the face of the earth, about the few that have gills and thus point to a remote origin of the burrowing race from aquatic forms. We can think of the time very long again when the pioneers left the fresh water and found a new world underground, how for long they probably enjoyed ages of peace, how, first, centipedes and long afterward moles disturbed their solitudes. In a rather different sense than was originally meant may we not say of the worm, "Thou art my brother"?

We have given three homely illustrations, but the point is, that everything is an illustration. Everything is equally wonderful if we know enough about it. It is true that we suffer from the limitations of our senses and of our sympathies, as well as of our knowledge; he who reads the rocks may never have seen the stars, and the coleopterist whose heart is in the right place as regards the beetle-world may never have heard the throstle sing. This is one of the defects of the quality we are discussing, we become preoccupied with one kind of wonder, but it is infinitely better than not having the quality at all. What we are driving at is, of course, what every nature-poet, from the Hebrew psalmist to George Meredith,

has felt, and perhaps Walt Whitman most keenly of all—the inextinguishable wonder of the world.

"I believe a leaf of grass is no less than the journey-work of the stars,
And the pismire is equally perfect, and the grain of sand, and the egg of the wren,
And the tree-toad is a *chef-d'œuvre* for the highest,
And the running blackberry would adorn the parlours of heaven,
And the narrowest hinge in my hand puts to scorn all machinery,
And the cow crunching with depressed head surpasses any statue,
And a mouse is miracle enough to stagger sextillions of infidels."

This is high doctrine, and who shall attain unto it? but it is an ideal of rational emotion worth striving after. There's the same idea more briefly put in Meredith's famous lines:

"You, of any well that springs,
May unfold the heaven of things."

It need hardly be said that with the growth of knowledge the precise basis of wonder may change. Our forefathers wondered at the lightning, we wonder at electricity; the child wonders at the sunbeam dancing about the room, we wonder at the Röntgen rays; the simple mind wonders at the snowflakes, we wonder at the results of the Great Ice Age.

But the moral of all this is obvious. The wonder of the world is a stimulus to our scientific intelligence, it incites us to discover the "open Sesame" for hundreds of Aladdin's caves, it makes us bow in reverence. Moreover, it is most obviously something to enjoy, to delight in more and more. We do well to recall that line of Goldsmith's, "His heaven commences ere the world be past." Do we not need some infusion of the simple delight in the earth which was expressed by Matthew Arnold in his "Empedocles on Etna," "Is it so small a thing to have enjoy'd the sun?"?

The Sense of Wonder and the Scientific Mood.—Our second general reflection is on the relation between science and wonder. Is not wonder the offspring of ignorance? Is not science the sworn foe of mystery? Do not all wonders disappear in the light of scientific day?

There are two separate questions here, first, whether the scientific outlook, which inquires into natural causes, is in itself antagonistic to the sense of wonder; and, secondly, whether the results of scientific analysis have not explained away much that used to be wonderful in human eyes.

The Three Moods: Practical, Emotional, and Scientific.—We must admit, of course, that the scientific mood is quite different from the emotional mood, just as it is quite different from the practical mood. The practical man is concerned with

possibilities of action, in obedience to Nature's primary command, "Be up and doing." The man of feeling is not concerned with loaves and fishes; he "hitches his waggon to the stars"; he seeks to "live on even terms with Time,"

> "Whilst upper life the slender rill
> Of human sense doth overfill."

The herbs and the bees, the birds and the beasts, send tendrils into his heart, claiming and finding kinship. In a hundred different ways he echoes Schiller's words:

> "O wunderschön ist Gottes Erde,
> Und schön auf ihr ein Mensch zu sein."

The scientific mood, on the other hand, has for its main intention to describe the sequences in nature in the simplest possible formulæ, to make a thought-model of the known world. The scientific man has elected primarily to know, not do. He does not seek, like the practical man, to realize the ideal of controlling nature and life, though he makes this more possible; he seeks rather to idealize—to conceptualize—the real, or at least those aspects of reality which are available in his experience. He would make the world translucent, not that emotion may catch the glimmer of the indefinable light that shines through, but for other reasons—because of his inborn inquisitiveness,

because of his dislike of obscurities, because of his craving for a system—an intellectual system in which phenomena are at least provisionally unified.

Now, it is surely best to say that the three dominant moods of man—practical, emotional, and scientific—which correspond metaphorically to hand, heart, and head, are all equally necessary and worthy, but that they are most worthy when they respect one another as equally justifiable outlooks on nature, and when they are combined, in some measure at least, in a full human life. A thoroughly sane life implies a recognition of the trinity of knowing, feeling, and doing. This spells health, wholeness, holiness, as Edward Carpenter has said.

One-sidedness, whether practical, emotional, or scientific, implies a denial of the trinity of knowing, feeling, and doing, a violence to the unity of life. When any one of the moods becomes so dominant that the validity of the others is denied, the results are likely to be tainted with some vice—some inhumanity, some sentimentalism, some pedantry.

When the practical mood becomes altogether dominant, when things get into the saddle and override ideas and ideals and all good-feeling, when the multiplication of loaves and fishes becomes the only problem of the world, we know the results to be vicious. The vices of the hyper-

trophied practical mood are—belittlement, baseness, brutality. To be wholly practical is to grub for edible roots and see no flowers upon the earth, no stars overhead. The monstrous practical man "will have nothing to do with sentiment," though he prides himself in keeping close to what he calls "the facts"; he cannot abide "theory," though he is himself imbued with a quaint Martin Tupperism which gives a false simplicity to the problems of life; he will live in what he calls "the *real* world," and yet he often hugs close to himself the most unreal of ideals.

Similarly, the hypertrophied emotional mood, unruled and uncorrelated, uncurbed by science, unrelated to the practical problems of life, tends to become morbid, mawkish, mad. What we have called rational wonder may degenerate into "a caterwauling about Nature." There may be overfeeling, just as there may be overdoing. The disastrous results of feeling without knowledge, of sympathy without synthesis (in the language of the learned), of effervescence without activity, are familiar enough in our own day.

Similarly (must we not confess?) the hypertrophied scientific mood has its vices—of overknowing, of ranking science first, and life second (as if science were not, after all, *for* the evolution of life), of ignoring good-feeling (as if knowledge could not be bought at too high a price), of pe-

dantry (as if science were merely a "preserve" for expert intellectual sportsmen, and not also an education for the citizen), of maniacal muck-raking for items of fact (as if facts alone constituted a science). Yet it is, like the other moods, a natural and necessary expression of the developing human spirit, and affords the foundation without which practice is empirical and soon helpless, without which emotion becomes sickly and superstitious.

We have recalled this doctrine of the three moods because it seems to place in proper perspective the question whether the scientific outlook is not prejudicial to the sense of wonder. The answer, of course, is that while we cannot have too much science, it is for ordinary men and women unwholesome to keep continually looking out at one window, and to keep the shutters on the others. Even for its own sake, science requires to be continually moralized and socialized, oriented, that is to say, in relation to other ideals of human life than its own immediate one of making a thought-model of the cosmos. Our science requires to be kept in touch at once with our life and with our dreams; with our doing and with our feeling; with our practice and with our poetry. Synergy and sympathy are needed to complete a practical synthesis.

Thus, we sympathize with the emotional or artistic recoil from science, because it is so often dis-

proportionately analytic. Science, like a child pulling a flower to bits, is apt to dissect more than it reconstructs, and to lose in its analysis the vision of unity and harmony which the artist has ever before his eyes. But if the artist has patience, he will often find that science restores the unity with more meaning in it than before.

Thus, too, we sympathize with the recoil from "a botany which teaches that there is no such thing as a flower," from "a biology which is all necrology." But have patience and you will find that the botanist brings the Dryad back into the tree, and that the necrologist makes the dry bones live.

We know how Wordsworth recoiled from irrelevant irreverent science. He spoke of

> "One, all eyes
> Philosopher! a fingering slave,
> One that would peep and botanise
> Upon his mother's grave."

Yet in the preface to "This Lawn a Carpet all Alive," Wordsworth wrote: "Some are of the opinion that the habit of analysing, decomposing, and anatomising is inevitably unfavourable to the perception of beauty." But "The beauty in form of a plant or an animal is not made less, but more, apparent as a whole by more accurate insight into its constituent properties and powers."

Our point just now, however, is rather different. It is simply that for ordinary men and women one of the conditions of sanity is an alternation of moods. Darwin was no ordinary man, yet he once admitted that it was a rest to lie under the trees and listen to the birds without bothering his head about how they came to be thus or thus. The great embryologist Von Baer once shut himself up in his study when snow was upon the ground, and did not come out again until the rye was in harvest. He was filled, he tells us, with uncontrollable pathos at the sight. "The laws of development may be discovered this year or many years hence—by me or by others—what matters it? It is surely folly to sacrifice for this the joy of life which nothing can replace." Life is not for science, but science for life. In short, it comes to this, that there is a time for science, and a time for emotion. It is a part of man's chief end not only to know nature, but to enjoy her forever.

The Sense of Wonder and the Results of Science.— Turning now to the second part of the question, we have to ask whether the results of science do not explain away the wonderful. Take the rainbow, for instance. It made Wordsworth's heart leap up; when he was a child, when he was a man.

> "So be it when I shall grow old,
> Or let me die."

But does the modern school-boy's heart leap up? His Physiology lessons have taught him to regard with extreme disfavour any such interference with the normal function of the vagus nerve; and, besides, his Physics lessons have explained away the rainbow. One remembers how Keats in his wrath cursed Newton for his share in robbing mankind of the wonder of the rainbow. What can one say except this, that the beauty of the rainbow is the same to-day as it was in the days of Noah, and that if we follow up the scientific interpretation of the rainbow, we come in sight of even greater wonders. When the half-gods go, the Gods arrive.

We watch the midnight sky flushed with the quivering Northern Lights—pale green and rose, crimson and gold—pulsating like the pinions of a hovering bird, and we wonder. We are at first saddened by our friend's remark that it is an interesting electro-magnetic phenomenon. But when we ask for details, and he tells us that corpuscles projected from the sun and bombarding the earth are affected by terrestrial magnetism, and travel in spiral coils toward the poles, till at a certain distance they exhaust themselves in giving off cathode rays, and so on, we begin to feel that we did not well to be sad. As we follow up the scientific unravelling of the mystery of the Aurora Borealis, we find that the world is even grander

than we knew, and we enjoy the Northern Lights better next time.

We ascend the hill among the woods on an autumn afternoon, and we look down on a sea of gold mingled with fire—all the glory of the withering leaves. Our botanical friend tells us of the breaking up of the green grains into chlorophyll and xanthophyll, how the latter is affected by the acidity of the cell-sap, how a special death-pigment, anthocyanin, may make its appearance, and so on; all the glory seems at first to fade into chemistry. But if we question the botanist a little we find that he has given us more than we have lost. We see that the hard-worked leaves must die, that it is better for the tree that they should fall, that they first surrender everything that they have that is worth having, till little more than skeleton and waste is left, that they are transfigured in dying, becoming for a brief space almost floral, and that their brilliance is a literal beauty for ashes.

Science is always trying to show us the wheels that go round, the wheels within wheels, and though the movement of the hands of the world-clock is not so mysterious as it used to be in the days of our childhood and in the days of our fathers, it is certainly more, not less, wonderful. Even when we are shown that the clock we know sprang from a simpler clock and that from a simpler still, the wonder deepens. If we ask Science to tell us

of the great clock-maker, she will be *quite silent*, for no man by searching can find out God, but if we ask how it precisely is that the main-springs work, or why it exactly is that the weights go down, Science will answer that *she does not know*. If we ask Science to tell us why there is a world-clock or a successor of world-clocks, at all, she will again be *quite silent*, for Science takes no stock in purposes; but if we ask how the first clock, from which all the other clocks are descended, came into being, Science will answer that *she does not know*.

This, then, is the real reason why the results of science cannot kill wonder, but should always increase it. Minor mysteries disappear, but greater mysteries stand confessed. Science never seeks to give ultimate explanations of phenomena, it describes their appearance in space and their sequence in time. The man of scientific mood becomes aware of certain fractions of reality that interest him; he tries to become intimately aware of these, to make his sensory experience of them as full as possible; he seeks to arrange them in ordered series, to detect their interrelations and likeness of sequence; he tries to reduce them to simpler terms or to find their common denominator; and finally, he endeavours to sum them up in a general formula, often called "a law of nature."

Let us take a concrete case. "The law of gravi-

tation is a brief description of *how* every particle of matter in the universe is altering its motion with reference to every other particle. It does not tell us *why* particles thus move; it does not tell us why the earth describes a certain curve round the sun. It simply resumes, in a few brief words, the relationships observed between a vast series of phenomena. It economizes thought by stating in conceptual shorthand that routine of our perceptions which forms for us the universe of gravitating matter."[1]

Conclusion.—We cannot do better than sum up by quoting Kant's famous passage:

"The world around us opens before our view so magnificent a spectacle of order, variety, beauty, and conformity to ends that, whether we pursue our observations into the infinity of space in the one direction, or into its illimitable divisions on the other, whether we regard the world in its greatest or in its least manifestations—even after we have attained to the highest summit of knowledge which our weak minds can reach—we find that language in presence of wonders so inconceivable has lost its force, and number its power to reckon, nay, even thought fails to conceive adequately, and our conception of the whole dissolves into an astonishment without the power of expression—all the more eloquent that it is dumb.

"Everywhere around us we observe a chain of causes and effects, of means and ends, of death and birth; and

[1] Karl Pearson, "The Grammar of Science," revised edition, 1900, p. 99.

as nothing has entered of itself into the condition in which we find it, we are constantly referred to some other thing, which itself suggests the same inquiry regarding its cause, and thus the universe must sink into the abyss of nothingness, unless we admit that, besides this infinite chain of contingencies, there exists something that is primal and self-subsistent, something which as the cause of this phenomenal world secures its continuance and preservation."

To speak of the primal and self-subsistent does not come within the strictly scientific universe of discourse, but to disclose the wonder of the world does. And it may be that those who realize this wonder most are those who follow it farthest and most fearlessly as it beckons, assured more and more fully of what is meant by Pascal's words, "In that thou hast sought me, thou hast already found me."

Do you ask why we have delayed so long over what every one admits—the wonder of the world? It is because this wonder is Nature's primary message to us, because the sense of wonder is at the roots of science and philosophy, because it has been and will always be one of the footstools of religion. We do well to mistrust any form of any one of these—science, philosophy, or religion—which does not deepen and heighten that wonder which is a primary attribute of every one who will be a minister and interpreter of nature. In all simplicity we must begin, though we need not

end with the quality alluded to in Emerson's child's-poem—"Excelsior."

> "Over his head were the maple buds,
> And over the tree was the moon,
> And over the moon were the starry studs
> That drop from the angels' shoon."

II

THE HISTORY OF THINGS

II

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The Antiquity of Things.—One of the most obvious results of the study of nature is simply the conviction that everything has a long history behind it. "Everything," as Bagehot said, "has become an antiquity." The human race seems to be several hundreds of thousands of years old, and yet man is a creature of yesterday compared with many of his present companions upon the earth. How long it is since the earth became fit to be the cradle and home of life we do not know, but it must be reckoned in millions of years. One enthusiastic calculator has stated, with almost painful precision, that the earth is 861,000,000 years old.

Things Change with the Times.—But it is not merely the length of years that impresses us; it is that everything—or rather the aspect of everything—has changed with the times. The present is in a sense a child of the past, but it is different from its parent. The earth has passed from phase to phase; one climate has succeeded another; there has been a procession of faunas and floras over the stage; we look back upon a great drama.

"There rolls the deep where grew the tree;
O Earth, what changes hast thou seen!
There, where the long street roars, hath been
The stillness of the central sea.

"The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands
Like clouds they shape themselves and go."
—"*In Memoriam*," CXXII.

Making of the Earth.—The story of the earth is a long story, retold every year in our schools and colleges, always becoming clearer and more picturesque as investigation continues. All that we require to do for our present purpose is to open the book here and there, to revive our impressions of the sweep of events.

In the book of the genesis of things there are no pages grander than those that deal—still somewhat vaguely—with the making of our solar system. The Nebular Hypothesis, which we owe to the genius of Kant and Laplace, is one of the boldest and most inspiring of all the scientific guesses at truth, and with sundry emendations and saving clauses this Nebular Hypothesis is adhered to by most modern investigators.

"This world was once a fluid haze of light,
Till toward the centre set the starry tides
And eddied into suns, that wheeling, cast
The planets." —*Tennyson's "Princess."*

"The history of a star," Professor R. K. Duncan writes, "begins with a nebula. A nebula is a vast swarm of meteorites colliding together. The meteorites are cold lumps of matter containing the chemical elements as we know them on earth. These meteorites in accordance with their gravitational attraction seek the centre of the swarm, collisions result, heat is evolved, and the temperature gradually rises."

Owing to the meteoric bombardment, the condensing and colliding mass becomes converted into incandescent gas, probably much simpler chemically than the original swarm. As the bombardment of meteorites ceases, the gaseous star begins to cool. Chemically, it retraces its steps, becoming more complex and heterogeneous again. It passes through the condition now illustrated by our sun or by Arcturus, and may eventually become in itself extinct, like "yon dead world, the moon."

One of the most attractive forms of the Nebular Hypothesis is that suggested by Professor Chamberlin. Laplace started with a gaseous nebula, Lockyer and G. H. Darwin start with a swarm of meteorites, Chamberlin starts with innumerable small bodies (planetesimals) revolving about a central gaseous mass. The central mass became the sun; knots or partial concentrations in the nebula became the nuclei of the planets; the res-

idue of diffuse nebulous matter is added to the sun or to the planets. The prominent features of this theory are (1) that it starts from a parent nebula of a spiral type, like most of those now existing; (2) that it supposes this nebula to consist of small bodies, like infinitesimally small planets; and (3) that it does not suppose any fundamental change in the dynamics of the system after the nebula was once formed.

Even to-day the work of creation continues, for stars are being born out of the fire-mist; even to-night it may be that a new star will be seen taking her place as a débutante in the splendid cosmic assembly. Some stars are growing cooler and more complex, recapitulating the history of our own earth; others seem to be growing hotter and less complex, perhaps suggesting what may happen here also in days to come.

Stages in the History.—The earth, then, probably had its beginning as one of the rings swirled off from a great nebular mass, the centre of which gradually condensed into our sun. It was once a rapidly rotating molten planet—one of many, for it may be noted that over five hundred planets —large and small—are now known, though Hegel tried to prove that there could not be more than seven. It probably had a deep atmosphere, part of which afterward condensed into the waters that cover the earth. Its molten ocean was pro-

foundly disturbed by solar tides, and it was perhaps a particularly high tide which made the earth give birth to the moon. This marked the first critical period in the history of our planet. "At the eventful time of parturition the earth was rotating, with a period of from two to four hours, about an axis inclined at some 11° or 12° to the ecliptic. The time which has elapsed since the moon occupied a position nine terrestrial radii distant from the earth is at least fifty-six to fifty-seven millions of years, but may have been much more." [1]

The moon thus arose as a sort of moult of the outer envelope of the hot earth. It was charged with steam and other gases under a pressure of 5,000 pounds to the square inch, but as it receded from the earth and the pressure continuously diminished it became "as explosive as a charged bomb, and steam burst forth from numberless volcanoes." The moon, in short, was only born to die. "While the face of the moon might thus have acquired its existing features, the ejected material might possibly have been shot so far away from its origin as to have acquired an independent orbit" [2] and some of the meteorites which now descend upon the earth may be returned portions of the early

[1] Prof. W. J. Sollas, Presidential Address, Section C, British Association, 1900. "Nature," September 13, p. 482.

[2] Prof. W. J. Sollas, *loc. cit.*

envelope, the bulk of which gave rise to the moon.

Soon after the birth of the moon the earth became consolidated (with a surface temperature of about 1170° C.) and the moon may have been influential in determining high-pressure areas and low-pressure areas over the surface of the crust, which may have had something to do with primitive depressions and elevations. This, as Professor Sollas says, was the second critical period in the history of the earth, the stage of the "consistentior status." It may have been forty millions of years ago, or much more.

When, with continued cooling, the temperature of the surface fell to 370° C., the steam in the atmosphere would begin to liquefy, and this was the first step in the origin of the oceans. The hot waters began to be localized in primitive faint depressions, and, acting energetically on the silicates of the primitive crust, began to be salt. In a manner difficult to understand a distinction was established between ocean basins and continental areas.

Through stages more or less like those hinted at above the earth has reached its present state. The vast nucleus or "centrosphere" seems to be practically solid, the melting point of the metals and metalloids being raised by the immense pressure. Outside the central mass there is "a

shell of materials bordering upon fusion," which Sir John Murray calls the "tektosphere." On this plastic shell there rests the heterogeneous and wrinkled crust or lithosphere, always slightly pulsating.

Then followed what may be called the wrinkling and folding of the earth's crust. If the solid core slowly contracted, the primitive crust in accommodating itself—through changes in the plastic shell or tektosphere—to the shrinkage within, would be buckled, warped, and thrown into ridges. "The contraction of the interior of the earth, consequent on its loss of heat, causes the crust to fall upon it in folds, which rise over the continents and sink under the oceans, and the flexure of the area of sedimentation is partly a consequence of this folding, partly of overloading."[1] The continents may be due to contractions of the whole crust, while mountains may be due to foldings of the outer layers through tangential stress brought about by contractions of the deepest layers.[2] Here we have to do with local collapses or dislocations of the crust and there with great lateral thrusts. As in pack ice, there may have been unyielding masses, which had to be piled one upon the other, while other masses may have been simply overlapped.

[1] Sollas, *loc. cit.*

[2] See the epoch-making work of Suess: "*Der Antlitz der Erde*" (1897).

Not less momentous were the great transgressions and regressions of the seas.

Sculpturing of Scenery.—Finally, we pass to a chapter in the earth's history which we can read with less uncertainty—the more detailed sculpturing and the making of scenery. There have been violent blows, such as earthquakes and volcanic eruptions; there have been drastic changes of climate, such as the Great Ice Age; but most of the factors which have wrought out the details of earth-sculpture seem to have been very gentle chisellings. The solid earth is weathered away by air and rain, by frost and snow; the waters wear the stones; the mountain is transplanted piecemeal to the sea; there is a ceaseless wear and tear of continents; there is a slow deposition of the soluble and insoluble results of denudation. As James Hutton said in his "Theory of the Earth" (1788), "little causes, long continuing," have wrought great changes.

The Hand of Life upon the Earth.—Nor can we overlook the influence of the hand of life upon the earth. The sea-weeds cling around the shore and lessen the shock of the breakers. The lichens eat slowly into the stones, sending their fine threads beneath the surface as thickly sometimes "as grass-roots in a meadow-land," so that the skin of the rock is gradually weathered away. On the moor the mosses form huge sponges, which

mitigate floods, and keep the springs welling and the streams flowing in days of drought. Many little plants smooth away the wrinkles on the earth's—their mother's—face, and adorn her with jewels. Others have caught and stored the sunshine, hidden its power in strange guise in the earth, and our hearths with their smouldering peat or glowing coal are warmed by the sunlight of the summers of thousands or millions of years ago. The grass, which began to grow in comparatively modern (*i. e.*, Tertiary) times, has made the earth a fit home for flocks and herds, and protects it like a garment; the forests affect the rainfall and temper the climate, besides sheltering multitudes of living things, to many of whom every blow of the axe is a death-knell. In fact, no plant, from bacterium to oak-tree, either lives or dies to itself, or is without its influence, direct or indirect, upon the earth. In arguing from the present rates of earth-weathering to those in past ages, geologists have not perhaps taken sufficient account of the degree in which the hand of life, especially in more modern times, has modified the extra-animate cosmic operations.

Similarly, as regards animals, the influence of the hand upon life upon the earth is manifold. On the one hand we see destructive agencies—the boring sponges and worms reduce the shells to sand, the Pholads and other larger borers help to

break down the most solid seashore rocks, the crayfish and their enemies, the water-voles, unite to make the river-banks collapse, the beavers have changed the aspect of large tracts of country, and so on through a long list.

On the other hand we see conservative agencies—the accumulation of enormous quantities of calcareous and siliceous ooze in the great abysses of the oceans, the formation of great shell-beds, the building of coral-reefs. We have already spoken of the work of earthworms, and when we add to that all that is done by hundreds of other subterranean creatures—from burial beetles to moles—and all that is effected by the microbes of the soil, we see a new meaning in the phrase "the living earth."

To sum up,

> "They say the solid earth whereon we tread
> In tracks of fluent heat began,
> And grew to seeming random forms,
> The seeming prey of cyclic storms,
> Till at the last arose the man."

This in more precise language the astronomers and geologists tell us, that the earth took form from a whirling crowd of meteorites; that after a stage of intense heat it began to cool and consolidate; that it got its centrosphere, its tektosphere, its lithosphere, its hydrosphere, its atmosphere; that as it

aged its skin became wrinkled—each wrinkle marking an event in its life as those on our faces often do; that it was exquisitely sculptured by fire and frost, by wind and rain, by river and sea; that it became fit to be a cradle and home of living creatures; that the hand of life has been working upon it for untold ages, forming chalk cliffs and coral reefs and coal beds; and that, finally, man has changed the face of continents—often reckless of results and ruthless of beauty.

There are obvious disadvantages in trying to outline in a few minutes the history of a hundred million years or more. The outline can have none of the picturesqueness of detail which gives charm and vividness to a well-told story. A brief outline is apt to suggest that everything has been cleared up, which is very far from being the case. Some chapters are extremely obscure and there are great difficulties in every chapter. Every year, however, the geologists are learning to read the history book better, and we have given the sketch as an essential part of our argument. It is an instance of the slow working of the cosmic mechanism towards a result which is wonderful. We can discuss it without any complications in regard to vitalism or psychism. The keynote of geological history-reading may be found in Hutton's famous sentence: "No powers are to be employed that are not natural to the globe, no action to be admitted

except those of which the principle was known, and no extraordinary events to be alleged to explain a common appearance."

Age of the Earth.—Before we consider the precise nature of the scientific interpretation of the past, let us pause for a moment to look back on the history objectively. We are impressed by the antiquity of it all. It is well known that at the end of the eighteenth century, or later, there was, even among geologists, a widespread belief that the habitable earth was some 6,000 years old—a belief arrived at by a peculiar wresting of the Scriptures. But when James Hutton began to see "the ruins of an older world in the present structure of the globe," when William Smith began to disclose the succession of strata and to tell the tale of age before age stretching back into a distant past, when Cuvier and others began to outline a succession of faunas and floras leading us back and back to the mist of life's beginnings, there was a reaction to an opposite extreme, and many began to think of the earth as a sort of inanimate Methuselah, "without beginning of days or end of years."

Slowly, attempts at measurement began. The geologists tried to measure the thickness of stratified rocks, sometimes estimated at 100,000, sometimes at 265,000 feet; they divided this by the observed rate of denudation and deposition (a foot

in a century or a foot in ten centuries), and the answer varied from twenty-six millions to six hundred and eighty millions of years. They tried other methods, such as computing the time required by the sea to become as salt as it is, and they reached other results. The biologists also had their finger in the pie, and made a modest demand for a slice of time sufficient to account for the evolution of living creatures, which some supposed would require a hundred million years, and others more, and others less. In short, both geologists and biologists drew without stint upon the bank of time, until the physicists reminded them that their credit was not quite unlimited. Arguing from the rate of cooling of the earth and sun and other insecure data, the physicists, notably Professor Tait and Lord Kelvin, refused to allow more than ten to twenty millions of years. Under pressure, the grant was afterwards increased to forty or even a hundred millions, which showed how flexible the calculations were. Within the last few years, however, since the discovery of radio-activity, since it became known that the earth is not self-cooling, but self-heating, the physicists have become willing to grant the geologists and biologists as much time as they want, say a thousand million years! All this uncertainty has been mainly due to the insecure data, which no amount of sound mathematics and ac-

curate arithmetic can make up for. The fact is that the age of the earth is an unsolved problem, but it must amount to many millions of years. We have dwelt upon this because in our conception of nature must be included the datum that the time required to bring about a result may be practically unimaginable in its amount. The span of the longest human life is but a tick of the geological clock. If genius be an infinite patience, we see it in the making of the earth. Nature is never in a hurry. She works "ohne Hast, ohne Rast."

> "One lesson, Nature, let me learn of thee—
> One lesson which in every wind is blown,
> Of toil unsevered from tranquillity."

Inorganic Evolution.—But what of the material of the earth throughout its history? There are perhaps a quarter of a million of quite distinct kinds of compounds on the earth; these are all due to diverse combinations of some eighty elements; and there is no reason to doubt that they have been gradually made in the course of the earth's cooling. But have the elements also a history? It is too soon to say much about inorganic evolution, but we may recall the known fact that radium gives rise to helium, and the probability that uranium gives rise to radium. There is here a hint of the transmutation or trans-

formation of elements. Sir William Crookes, for instance, has offered suggestions as to the possible origin of the chemical elements from a formless primordial stuff or "protyle," wherein all matter was in the pre-atomic state—potential rather than actual. He has gone the length of suggesting that the chemical elements owe their stability to their being the outcome of a struggle for existence in which the most stable survived.

Let us take a paragraph from Prof. R. K. Duncan's marvellously clear exposition of "The New Knowledge."[1] "It may be true that all bodily existence is but a manifestation of units of negative electricity lying embosomed in an omnipresent ether of which these units are, probably, a conditioned part. Mass comes into existence only as the negative electron, assuming motion, carries with it a bound portion of the ether in which it is bathed; and furthermore this mass depends solely upon the velocity with which the negative unit moves. Our negative unit on receiving mass becomes a "corpuscle" endowed with the primary qualities of matter superimposed upon those of electricity. Corpuscles congregating into groups or various configurations constitute essentially the atoms of the chemical elements, locking up in these configurations super-terrific energies and leaving

[1] Prof. R. K. Duncan, "The New Knowledge," 1905, p. 252.

but "a slight residual effect" as chemical affinity or gravitation with which we attempt to carry on the work of the world. These atoms, congregating in their turn as nebulæ and under the slight residual force of gravitation, condense into blazing suns. The suns decay in their temperature and become ever more and more complex in their constitution as the atoms lock themselves, developing up into the molecules of matter to form a world. We see the molecules growing ever more and more complex as the world grows colder until we attain to organic compounds. We see these organic compounds united to form living beings and we see these living beings developing into countless forms, and, after æons of time, evolving into a dominant race, which is us."

This rather takes one's breath away, and of course the clear-headed author's use of the words "we see" is highly metaphorical. In this case seeing means believing. An outsider can hardly refrain from suspecting that the evolutionary physicists tend to be a little impetuous, perhaps even metaphysical. Is there not a tendency to make a demiurge of the ether, which, after all, is but a necessary hypothesis? It seems a little uncertain whether it is "some mysterious form of non-matter," as is generally believed, or whether it may not be the lightest and simplest of the elements, as Mendeleeff suggested. Just as Berkeley

resolved "matter" into affections of "Spirit," so the modern physicists resolve matter into "a mode of motion," and we cannot think of the origin of motion any more than we can think of the origin of spirit. Matter is resolved into molecules, which are resolved into atoms, which are resolved into corpuscles surrounded by positive electricity, and a corpuscle is a moving unit of negative electricity together with a ' bound" portion of the surrounding ether which is its mass. It is impossible for ordinary mortals to think of motion apart from "something" moving, and the only "somethings" left to us seem to be electricity and ether. It seems all to end in motion and mystery, which is perhaps a wholesome result. The common denominator of physical science allows abundant scope for transcendental interpretation.

"Ins Innre der Natur dringt kein erschaffner Geist."

Interpretation of the Past.—We have given an outline of the process of becoming which seems to have led to the present phase of inanimate Nature. Let us now consider what we have got.

Starting from processes which go on to-day—whether these be weathering or star-making—science seeks to reconstruct the stages in the genesis of the earth. It tries to make a rationally connected history by showing that particular sets of conditions lead on to particular sets of

results,[1] and in so doing it must always argue from what goes on now to what may have happened long ago.

Just as Darwin argued from the experience of breeders in the nineteenth century to what might have occurred in natural breeding millions of years ago, so Lyell, before him, argued from processes of earth sculpture going on under his eyes to what might have occurred in ancient days when there was no eye to see. This is the only path of interpretation available, but it is obviously one on which we must walk warily. In appreciating the value of certain factors we must work from the present backward, but it is possible that the present state of affairs may give us, so to speak, a false start.

Development and Evolution.—It seems a confusion of thought to speak of the evolution of the earth, as if it were like the evolution of organisms. We should rather compare the story of the earth to

[1] We have to show that A, B, and C are the antecedent conditions of D, E, and F; that A, B, and C are all the antecedents of D, E, and F; that D, E, and F are all the consequents of A, B, and C. From actual experience we must give good reason for believing that the sequences we suppose to have occurred are in line, in principle at least, with the sequences we study to-day. Obviously, too, the modal interpretation that we give must be as simple and generalized as possible. As we soon discover that the same kind of sequence occurs and has occurred over and over again, we make a formula for it.

the story of an individual development. It is the same earth all through, just as it is the same organism all through. In organic evolution, however, we have to do with races, with a succession of new forms, arising out of old forms, which either disappear or continue to exist alongside of their descendants. We may perhaps speak of the evolution of the chemical elements, of which we know very little, but we cannot accurately speak of the evolution of the earth. It is not the survivor among many earths which arose from the womb of a Protogæa. It has had a long development, that is all. This may seem verbal pedantry, and yet fallacy is apt to arise from confusing continuous individual development with racial evolution.

In the development of an individual organism we always start with a more or less rich inheritance which is the product of a long evolution in previous ages. We regard the development as a gradual realization of the "given" potentiality, as a gradual expression of what is already there. We believe that in an appropriate environment stage succeeds stage in an absolutely predetermined fashion. There is an identity of essential substance throughout, and the stage of to-day contains that of to-morrow, and must, in normal conditions, give rise to it. New properties, new modes of behaviour, emerge day after day, and although we do not

know *how* the potential becomes actual, we can watch the process. In an absolutely transparent egg, like that of the moth *Botys hyalinalis*, we can follow the whole visible process with unbroken continuity—the minting and coining of the caterpillar out of the egg, the emergence of obvious complexity out of apparent simplicity. We cannot, of course, see the development of the caterpillar's instincts any more than we can see the growth of the chick's mind by any amount of embryology, but we see what takes place, and it looks like an automatic autonomous unfolding. The only way in which we can meet the difficulty of the emergence of the apparently new is by supposing that the apparently new was potentially there in the beginning.[1] In short, we read back the consequents into the antecedents. So, in the development of the earth, we have to do with what we believe to be a perfectly continuous series of distributions and re-distributions of matter and energy in the ambient ether. The meteorites become a nebula, and the nebula becomes a star. It differentiates and integrates as it cools, and we try to chronicle stage after stage. We do not sup-

[1] Later on we shall have to qualify this by recognizing that the living organism is in a real sense 'creative,' using its experience to make thereof something new; but even this creative power is 'given,' that is to say, inborn.

pose that the sum-total of matter and energy in the whole system of things suffers any loss or makes any gain. If apparently new properties arise, we believe that they are old properties in new guise. We can make apparently very new things ourselves, such as dynamite, but we know that the properties of dynamite can be resolved into the properties of simpler things. Even when we discover a new thing like Radium, with altogether unexpected properties, we soon follow it up by discovering radio-activity in many other cases. It may be, for all we know, an intrinsic property of matter to emit rays. In any case, we revise our conception of what is "given," and say that there is nothing new under the sun. In short, in the history of the earth, we believe we have to do with a continuous natural development, in which antecedents pass over into their consequents, and we feel no need for any cause in the strict sense except the first cause which is taken for granted throughout.

Later on, we shall try to show that this way of looking at things must be somewhat enlarged when we come to the emergence of living organisms upon the earth, when we have to do with autonomous agents, when we study intelligent behaviour, when we face the biggest fact in all science—man, with his ideas and ideals—a thinking reed, who, if the universe should crush him, would still be

nobler than the universe in knowing that he was crushed.[1]

Mechanical Categories Suffice.—If we leave out of account, in the meantime, life and all results that can be referred to the hand of life, and consider the history of the inanimate world, either as regards its great events or in such details as the making of a volcanic mountain, the carving of a valley, or the formation of a river-system, we find that it is possible to give a more or less probable mechanical account of the various sequences which may have led up to the results we know and admire. Thus the history of the Niagara Gorge and its relation to the Great Lakes, past and present, has been worked out—up to a certain degree of security—in a most beautiful and convincing manner. From what we know of present physical and chemical processes we can interpret the past with considerable precision—with increasing precision every year. And the general result which we must bear in mind is that mechanical categories suffice. In inanimate nature, science sees a sys-

[1] "Pensées de Pascal," Chap. II, x.

"L'homme n'est qu'un roseau, le plus faible de la nature, mais c'est un roseau pensant. Il ne faut pas que l'univers entier s'arme pour l'écraser. Une vapeur, une goutte d'eau, suffit pour le tuer. Mais quand l'univers l'écraserait, l'homme serait encore plus noble que ce qui le tue, parce qu'il sait qu'il meurt; et l'avantage que l'univers a sur lui, l'univers n'en sait rien."

tem whose relations of sequence admit of being re-stated by means of equations of motion. Whether we try to interpret the history of the solar system or the genesis of minerals, the origin of a mountain chain or of the granite that helps to compose it, the work of a glacier or the formation of a stalactite, we work with reliable formulæ of gravitation, attraction and repulsion, hydrostatics and thermodynamics, and so on—*i. e.*, with purely mechanical formulæ, and we do not find that they are insufficient. If we take the known properties resident in matter and the laws of energy as data, we can plausibly reconstruct any particular part of the inanimate world. "Gebt mir Materie," Kant said, "und ich will daraus eine Welt schaffen."

Do Things Make Themselves?—When we consider these two general results, first, that the becoming of the earth reads like a story of continuous individual development, as of an egg into a chick; and, second, that in our redescription of both the present and the past of any particular part of inanimate nature the categories of mechanics are sufficient, we get a strong impression that there is much truth in what Kingsley made Nature say in his immortal "Water-Babies,"—"I make things make themselves."

We look back on the history of inanimate nature and we see obvious complexity arising out of

apparent simplicity—a nebula becomes an intricate earth; we see a higher order emerging out of a lower—a system of sun and planets is established; we see a multitude of parts working together with the smoothness of a well-made machine; we see what we call beauty and what, if we had been the makers of the history, we should certainly have called progress. It is very wonderful. And yet, in a certain sense, are we not warranted in saying that Nature has made herself what she is, *i.e.*, that any particular result is the natural predetermined predictable outcome of the antecedent conditions? Few feel any particular necessity for invoking the aid of a *deus ex machina* to account for the frost-flowers seen on the window-pane on a winter morning—which, in fairy-like beauty, remain for a brief space as external reminiscences of the evening talk—but each spray of that frosty pane is molecularly as complex as the Milky Way seems to our eyes. It has been said that the undevout astronomer is mad, but Laplace was *as astronomer* quite right in saying in answer to Napoleon's famous question regarding God, that he had no need of that hypothesis. He was right, in the first place, because science is a perfectly definite business of formulating sequences in terms of sense-experience, and is false to its task when it obscures its deficiencies by interpolating formulæ of an entirely different order. And he

was right, in the second place, because in the scientific interpretation of any particular occurrence in inanimate nature, we have no reason to believe that mechanical categories are not quite sufficient. To conclude, however, that this scientific interpretation is in terms of concepts which are self-explanatory, or that it is the only interpretation, or that it is in itself a satisfying human interpretation, is quite another matter.

Recoil from the Scientific Position.—The scientific conception of the physical universe as a sort of world-egg developing of itself, capable in virtue of the properties resident in it of passing from phase to phase in the course of æons, like a machine wound up not only to go but to improve itself by going, is repugnant to many minds, and various attempts have been made to wriggle away from it. Fundamentally, perhaps, this recoil is due to a misunderstanding of the aim of science, a failure to see that a descriptive account of occurrences is not an explanation of them, and cannot be put in opposition to other quite incommensurable ways of summing up the history. But let us consider for a moment how some have tried to put a brake on the impetuously driven chariot of science.

(1) It is useful to point out that many of the riddles of inanimate nature are still unsolved, for nothing is more prejudicial to progress than giving

a false simplicity to facts, or "giving to the ignorant, as a gospel, in the name of Science, the rough guesses of yesterday that to-morrow should forget."[1] He would be a bold man who should say that he thoroughly understood the tides, not to speak of the weather, and no astronomer pretends that he really knows how the worlds were formed. He thinks that he is on the sure track of knowing, that is all. How little we know of the possible origin of the eighty or so different kinds of elements? But this sort of *argumentum ad ignorantiam*, while healthy enough within limits, can give no permanent satisfaction. It crumbles when we read the history of scientific progress in a single century. The lap of the future is full of scientific puzzles, but who will pick out those that are insoluble, and pin his faith on a gratuitous and really presumptuous *ignorabimus?*

(2) Another form of the same kind of argument is also useful within limits. It consists in pointing out that many of the terms currently used in chemico-physical interpretations of inanimate nature are not really simple, but are big with mystery. What is gravitation, for instance, or what is electricity, or what is matter itself? If this argument means that science starts by postulating something "given," it is sound; but if it says that gravi-

[1] W. Bateson, "Materials for the Study of Variation," London, 1894.

tation or electricity is irreducible, it is illegitimate. It is faint-hearted and premature to assume that what is at present irreducible will remain irreducible, unless some good reason can be given for so judging. It yields no permanent satisfaction when we reflect on the past, when we consider the success which has attended scientific efforts to reduce the number of supposed separate entities or powers. The use of "William of Occam's razor"—*Entia non sunt multiplicanda præter necessitatem*—has already had its reward. It has given us a deeper conviction of the "oneness" of Nature. We need simply recall how "Caloric" was eliminated, yielding to the modern interpretation of heat "as a mode of motion"; how emanations of "Light" had to follow, when the undulatory or the electro-magnetic theory of their nature was established; how "Force" itself has become a mere measure of motion; and how even "Matter" tends to be resolved into units of negative electricity, carrying with them a bound portion of the ether in which they are bathed. By all means, let us have a criticism of the categories of science—which is indeed part of the business of a useful philosophy—but let us avoid the dogmatism of asserting that the scientific unification of nature has reached its limits. "God said, 'Let Newton be,' and there was light," and another Newton may be born to-morrow.

(3) Another line of argument is less easily dealt with. The scientific position is that natural happenings are due to properties resident in the given material, whether it be a nebula or a dew-drop. But do we know all the resident properties? May there not be resident properties as yet undiscovered? May there not be resident properties which are by their very nature beyond scientific discovery? The answer to this argument is Experiment. We can work only with the resident properties that we know, and if by experiment we get a result which cannot be accounted for in terms of the known resident properties, then we must admit that some resident properties have escaped detection, and are there though we cannot define them. As a matter of fact, this commonplace of scientific procedure has often led to the discovery of previously unknown resident properties. But if we can give an adequate account of an occurrence in the laboratory in terms of known resident properties, we are justified in trying to do the same for the grandest cosmic phenomena. If we could convince ourselves, as some have convinced themselves, that a sum of money can disappear from a safe without any opening, we should have to admit that there are properties resident in matter that the physicist is unaware of. But who can say that he knows of any occurrence in inanimate nature which the known resident properties are

obviously incapable of accounting for? If the letters of a jumbled fount of type or the fragments of a smashed machine were to rise up and arrange themselves in working order, we should have to revise our mechanical categories; but we do not know of any such phenomena in the ordinary course of inanimate nature.

It is open to any one to say that there is a spirit in the nebula and a Psyche in the dew-drop—just as Haeckel says that there is a permanent soul in every atom; but if these are supposed to be operative, the scientific analyst must say that he finds no need for the hypothesis, since the laws of motion suffice for him, while, if they are supposed to be inoperative, the scientific analyst usually applies William of Occam's razor without remorse.

The form in which this line of thought seems most attractive is briefly this. When we consider any particular corner in the inanimate world, say, the making of the Niagara Falls or the making of the frost-flowers on the window, we do not require in our redescription more than mechanical formulæ. But when we consider Nature not in isolated pieces but as a harmonious whole, when we recognize the progressive order, the orderly progress, and the beauty of it all, when we go on to recognize the probability that the earth has been the parent of its tenants, then we must read back into the world-egg with which we start a

potentiality of giving rise to all that follows, and thus the Lowest Common Denominator of Science becomes the counterpart of the Greatest Common Measure of Philosophy.[1]

Nature of Scientific Interpretation.—But the more immediate answer to the recoil from the scientific position is to be found by considering what most modern workers mean by scientific interpretation.

The scientific interpretation of inanimate nature is always after this pattern: Given a certain collocation of material particles in certain conditions, the result after a certain time will be so and so.[2]

The problem is to redescribe natural happenings in the simplest available terms, namely, in terms of mechanics in the wide sense. Some of the terms used are simpler or more irreducible than others; thus that form of mutual attraction which we call gravitation is probably more irreducible than what we call chemical affinity. Some which seemed irreducible in the past have undergone simplification; thus Heat is no longer an "element" or an "entity" or a "force"—but

[1] To identify them violently, as a recent writer does, who calls the Ether "the fountain of all Being," "the hitherto unknown God," seems to us to be a complete misunderstanding, and as grotesque an anthropomorphism as any savage is guilty of.

[2] It need hardly be said that in many cases we have to write *uncertain* instead of *certain*, but let that pass.

"a mode of motion." Some which are not reducible at present will probably undergo simplifying analysis in the future, for the physicist may some day discover the true inwardness of gravitation, and be able to tell us what really happens in the invisible world when the apple falls in the orchard. Progress is continuous toward the ideal of redescribing all the occurrences in inanimate nature in terms of the laws of motion; one fastness after another has given up its keys; one riddle after another has been read; all of which means a scientific demonstration of the unity of nature.

It is true that the redescriptions which are given of intricate occurrences do not sound simple; the more thorough they are, the more do they pass beyond the comprehension of the unlearned and become preserves for the mathematically minded; even more than in ancient days is it true that the portal of the scientific academy bears the legend, "Let no one ignorant of mathematics enter here." But the point is that the assumptions of the mechanical interpretation of inanimate nature are simple, in the sense that the laws of motion are simple. It comes to this, then, that the birth and death of worlds, the harmony of the spheres, the sweep of our whole solar system in space—in short, the greatest of cosmic phenomena—submit to being studied by the same exact methods, and to being redescribed in the same simple terms as the

thunderstorm and the dew-drop, the sublime architecture of the mountains and the evanescent beauty of the frost-flowers on the window pane. It surely shows us that we live in a universe not a multiverse, if such things be so; the very fact that the world is scientifically intelligible shows that there is a rational unity behind it; it surely shows us that Man is no freak of nature who can hold the earth in a balance and measure the heavens in his scale. Strictly speaking, science redescribes and reconstructs by means of symbols—conceptual formulæ—such as matter, electricity, ether, gravitation, chemical affinity. There must be the counterfoils of reality in these, else science would not work out practically as it does; we could not trust it and predict by means of it as we do. But a law of nature is no longer regarded by any scientific man as a necessity which things have to obey; it is rather a summary expression of certain constancies of scientific experience.

Strictly speaking, as regards inanimate nature, science finds no true causes. It is a mechanical axiom that what is in the results was also in the conditions, and what science is continually doing is to show that one particular collocation of matter and energy passes into another. Sometimes the resultant is obviously just the components over again and no further explanation is needed or possible; in many cases, however, science has

simply to record that the sequence occurs. How it exactly occurs is not known. Strictly speaking, science must always start with a good deal "given," which it takes for granted. In the particular case we have been discussing the something "given" is the nebula. The scientific conception of this is that it was like the nebulæ we see in the heavens to-day, a whirling system of meteorites or planetesimals. At the same time, if it be true that not only the inanimate but the animate as well has grown out of the nebula, then we must read back into it all the grandeur of all its consequents. Finally, it must be clearly understood that science never even asks the irrepressible question, *why* has all this become as it has become?

Thus science recognizes the fundamental mysteriousness of things, (1) as regards its Common Denominator; (2) as regards the chains of sequence it chronicles, but does not explain; (3) as regards the beginning.

As one of our philosophers[1] has said: "Some people write and talk as if the discovery of the natural cause of an event meant the withdrawal of the event from the sphere of divine agency. According to this way of thinking, the gradual success of science in reducing all phenomena to natural law is tantamount to the banishment of God from the universe. He becomes a hypothesis that

[1] Prof. A. S. Pringle-Pattison.

is not required, or if any room be left for his action, it must be at some point in the "dark background and abysm of time" when the orderly system of the universe is supposed to have been set agoing.

Now, what is the misunderstanding in the minds of those who think that there is some opposition or antithesis between saying that the Earth grew out of a nebula and saying that God created the world by the word of His power? The basal misunderstanding is a failure to see that the word ultimate does not occur in the scientific dictionary. For particular purposes—of formulating and thereby perhaps working with natural processes—science pursues certain methods and reaches certain results. Its outlook is in no way inconsistent with the emotional outlook, but it seems fairly obvious that one must not try to make one sentence of the two statements, "O wunderschön ist Gottes Erde, und schön auf ihr ein Mensch zu sein," and "Bodies attract one another with a force proportional directly to the product of their masses and inversely as the square of their mutual distance." There is no reason to surrender the philosophical outlook, with its conviction that "In our life alone does Nature live"; but we must not mix this up in any way with an inquiry into radio-activity.

Again, the aim of science is not to explain but to redescribe in simpler terms, to find a common

denominator, but its interpretations are always in terms of conceptual formulæ—such as matter, energy, ether, gravitation, chemical affinity, and so on—which are not themselves self-explanatory; which are in fact only intellectual counters, symbols of the mysterious reality.

Again, science continually tries to refund one natural phenomenon into another, seeking to show that given certain conditions A, B, C, certain results D, E, F will always follow. When D, E, F are simply A, B, C in a new guise, as when we get a single resultant force out of several components, the scientific interpretation is complete. When D, E, F are quite different from A, B, C, as when we get water by combining hydrogen and oxygen, we know that the conditions have somehow passed over into the resultants, but we cannot tell how the result is as it is. This is true of most scientific interpretations. They do not deal with causes in the sense in which we speak of a personal agency as a cause.

Again, science in its historical treatment of things always starts from something "given," which it does not explain, which in the last resource it cannot explain. From this something "given" there seems to be a continuous development, and it is therefore believed that this antecedent had in it the potentiality of all that comes out of it. Thus, if order, progress, harmony,

beauty, intelligence, come out of it, they must somehow have been potentially in it. We may try to substantiate the original antecedent in abstraction from its consequents, we must do so in pursuing the scientific method. We may try to think of the nebula as a whirling mass of meteorites, and nothing more; but if the whole solar system came out of that, we must as philosophers, if not as scientists, say that "There is nothing in the End which was not also in the Beginning," and if there is Logos at the end, we may be sure that it was also at the beginning.

With this explanation, is it not possible to return without repugnance to the scientific position with its central idea of a continuous natural development?

But some one may say, I am not clear in regard to what you have said regarding science not pretending to give explanations, but this much I gather, that the picture you leave with us is that of a world developing of itself. That is so, if you do not forget to supplement this with the quotation from Kant with which we closed the previous lecture: "The universe must sink into the abyss of nothingness, unless we admit that, besides this infinite chain of contingencies, there exists something that is primal and self-subsistent, something which as the cause of this phenomenal world secures its continuance and preservation."

What we have been trying to show is, that the conception of this earth of ours with which Science works, and works to such purpose—both theoretical and practical—is the conception of a continuous natural development in which any particular series of sequences is describable in terms of matter and motion. But why should the scientific mind be so afraid of the insinuation of a metaphysical principle? Simply because it is a confusion of thought that paralyzes intelligence.

What we are driving at has been clearly stated by Prof. A. Seth Pringle-Pattison:[1] "Natural explanations—*i. e.*, regulated sequences and co-existences of phenomena—are what every science has to seek in its own sphere; and, accordingly, science justly regards as suspect the explanation of any phenomena by the immediate causality of a metaphysical agent. The interjection of such a causality into the empirical connections which she seeks to unravel, she treats as a form of *ignava ratio*." "It makes the investigation of causes a very easy task," says Kant, "if we refer such and such phenomena immediately to the unsearchable will and counsel of the Supreme Wisdom, whereas we ought to investigate their cause in the general mechanism of nature. This is to consider the labor of reason as ended,

[1] "The New Psychology and Automatism" in *Man's Place in the Cosmos and Other Essays*, 2nd ed., 1902.

when we have merely dispensed with its employment."

Do we mean, then, that from such a beginning as a swarm of meteorites, the whole earth with all its beauty and order has grown? That is what science seems to suggest. What a poor and inadequate beginning, you may say, for such a wonderful result. But has any one a right to say this? Whence came the swarm of meteorites and all that they contained, what is electricity, what is the ether? What is the reality behind all the counters whose moves it is permitted to science to formulate and eventually to predict?

Do we mean that from such a beginning the whole earth with all its beauty and order has grown without direction from without? That is what science seems to say, that the direction is *from within*, that the Kosmos was already in the Nebula, that there never was any chaos at all, that there is nothing in the end which was not also in the beginning. And if you like to add, "In the beginning was the Logos," science has no word to say against it.

Lafcadio Hearn tells us that in the house of any old Japanese family the guest is likely to be shown some of the heirlooms. . . . "A pretty little box, perhaps, will be set before you. Opening it you will see only a beautiful silk bag, closed with a silk running-cord decked with tiny tassels. . . .

You open the bag and see within it another bag, of a different quality of silk, but very fine. Open that, and lo! a third, which contains a fourth, which contains a fifth, which contains a sixth, which contains a seventh bag, which contains the strongest, roughest, hardest vessel of Chinese clay that you ever beheld. Yet it is not only curious but precious; it may be more than a thousand years old."

Historical natural science has to do with a similar process of unwrapping—it removes one silken envelope after another, trying to unravel the pattern and count the threads—and what is finally revealed, though it seem to the careless but as hard clay, is something—if we may say something—so very old, so very wonderful, that science can give no name to it.

III

ORGANISMS AND THEIR ORIGIN

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The Variety of Living Creatures.—The earth has come to be tenanted by practically countless hosts of living creatures, whose ranks are continually being thinned, and continually being recruited. There are legions upon legions of species, that is to say, different kinds of living creatures—groups of individualities, worthy of a specific name, because they differ more from the nearest group than brothers or cousins differ from one another, and because they breed true with their own kind. What a motley assemblage it is! There are plants so minute, *e. g.*, the Bacteria, that many can hang on the point of a needle; there are the hyssops on the wall and the cedars of Lebanon. There are animals so minute, *e. g.*, the Trypanosome of Sleeping Sickness, that we require our best microscope to see them, and there are the gigantic Saurians of by-gone ages, and the still surviving giants like the elephants and the giraffes and the great whales. The simplest organisms are single cells—invisible units of living matter; the more complex are vast cities of cells with millions of component units. What variety of habitat there

is; their lines are gone over all the earth. The explorers find no corner where life has not outrun them. Nansen found minute living creatures in ice pools in the Farthest North; the Natural History of the Antarctic already fills several large volumes. On the earth and under the earth; in all the waters high and low; on the mountain tops and in the great abysses of the deep sea; free in the air and fettered in the penetralia of other creatures, life abounds. What a long gamut of activity there is, from the dull sentience of many of the simplest, which seem sometimes to have no more than one distinct action or reaction, and the sleep-life of the higher plants, to the complex instinctive routine of ants and bees, and the intelligent behavior familiar to us in the big-brained educable birds and mammals. How difficult it is to find what is essentially characteristic of them all as distinguished from the inanimate creation. But that is what we must now try to do.[1]

Characteristics of Livingness.—The great oak is instinct with life in every leaf and twig and rootlet, it is a whirlpool of whirlpools of intensely active corpuscles, yet it outlives many generations of men, and stands, like the tree of Igdrasil, as an emblem of eternal life. What a contrast to the earth beneath our feet, which we usually call

[1] See J. Arthur Thomson, "The Science of Life," Blackie & Sons, Glasgow, 1899.

"lifeless." But a flash comes from a passing cloud, and the oak is dead. Where is our clear contrast now? We watch a bird flying overhead: "it rests upon the air, subdues it, surpasses it, outraces it." What a contrast to the stone beneath our feet, which we usually call "inert"! But the stone is thrown, and the bird falls dead. Where is our clear contrast now? A slight blow on the back of the head, and what we call "life," where is it? It is extremely difficult to find an absolute criterion between what once was living and what now is dead. In many cases, we can obviously say of the killed creature that its machinery is shattered; in other cases, we can only say that the wheels have ceased to go round. A few hours ago the eggs of that bird were living—intensely living—in her nest, but the bird is dead and the eggs are growing cold. Life is slipping away. Take them still and hatch them in the incubator, and you will soon see how really living they are. Take them next day and you might as well take stones. Professor Waller says there is an electrical "blaze reaction" which will infallibly tell us whether the "vital spark" has gone out in the forsaken egg or in the wind-blown seed, but we do not know much about it. The sure test of livingness or non-livingness is, of course, in results.

Puzzling Phenomena.—The phenomena of "latent life" are very puzzling, and deserving of far more

attention than they have as yet received. The dried seed may remain alive without detectable signs of life for several decennia (though not since the time of Pharaoh, as used to be said). Certain little threadworms (Anguillulidæ) may be kept dry without any discernible hint of life for fourteen years, and yet become vigorous again when put into water. At any time during the fourteen years this revivification may occur, but not in the fifteenth year! What is life that it can remain so long without asserting itself and yet without dying? It would be interesting to arrange on a long inclined plane all the phenomena of anæsthesia, narcotization, sleep, coma, suspended animation, fainting, trance, catalepsy, and dying in man; all the phenomena of death-feigning, animal hypnosis, paralysis, hibernation, latent life, and dying in animals. The phenomena of local life are also remarkable. The excised turtle's heart may go on beating for many days after the animal has been made into soup. We speak of shattering the machine, but a decapitated turtle has been known to walk about. Living, we say, means a consensus of all the living parts, and yet a part may be as good as the whole. In the case of hundreds of plants, a small fragment carefully nursed will regrow the perfect organism, and the same is true of fairly complex animals, such as sponges and polyps and worms. From one Turbellarian worm

cut into twelve pieces, twelve complete worms may be obtained. We must also recall that the potentiality of the whole life lies in a microscopic germ-cell, and may be unrealized for years. A complete inheritance, rich in initiatives, endowed with the gains of past ages, may be condensed in a microscopic egg-shell and in a sperm-cell 100,000 times smaller. Moreover, the experimental embryologists have shown us that, unity as the germ-cell is, a part may be as good as the whole. One egg may give rise to twins, or triplets, or quadruplets, or even to many perfect embryos. From one-thirty-seventh of the egg of a sea-urchin Prof. Yves Delage reared an embryo—able to live for some time. All this, and much more, must be borne in mind when we think of the characteristics of livingness.

Although no one is wise enough to tell completely what is meant by the simple word alive, there may be utility in trying to state some of the characteristic features of living organisms.

From the Chemist's Point of View.—Looking at organisms from the chemist's point of view, we see that the physical basis of life invariably includes those carbon-compounds known as proteids, which are among the most complex kinds of matter in the world. The component elements of living creatures are just the common elements found in their surroundings, but the make-up of

the organic compounds is very intricate. Thus the elements which enter into the composition of a proteid are Carbon, Hydrogen, Oxygen, Nitrogen, and Sulphur, but the chemical formula of the proteid known as white of egg is $C_{204}H_{322}$-$N_{52}O_{66}S_2$. The living body contains such a mixture of these complex compounds that we cannot put our finger on any one kind of stuff and say: This is protoplasm or living matter and nought else. It may be that there is an essentially important kind of substance which acts like a ferment on the complex cellular materials brought within its sphere of influence, but it is more probable that there is no one substance which should be called protoplasm. It seems likely that living matter is a mixture (certainly no jumble!) of proteids and other highly complex substances, owing its virtue to their coöperative interaction, just as the secret of a firm's success may depend not on any one partner by himself, but on their combination of talents.

Although we cannot analyze living matter, nor thoroughly interpret all the changes of material implied in living, we can trace some of the chains of chemical sequence. We can follow the food through various transformations till it becomes part and parcel of the living body; we can catch the waste products formed during activity—the ashes of the living fire—we know that there is

a twofold process of building up and breaking down, of winding up and running down, of construction and disruption, and we know much in regard to important processes of fermentation that go on—much more, indeed, than we understand. We are in the position of visitors to some great manufactory who are permitted to see the raw materials passing in, some stages in their transformation, and the finished products passing out, but who are not allowed entrance to the "secret room" where the gist of the business is hidden.

When more is known in regard to the chemistry of the living body, it may be possible to bring the changes into better line with those which occur in inorganic things and in the laboratory with organic things, but meanwhile we cannot redescribe the activity of the living creature in terms of chemical formulæ,[1] unless we throw away the child with

[1] It is sometimes asserted by careless writers that the progress of physiology in the last half-century has made it possible to redescribe vital phenomena in terms of physics and chemistry.

"To me," says Bunge, a physiologist of undeniable standing, "the history of physiology teaches the exact opposite. I think the more thoroughly and conscientiously we endeavor to study biological problems, the more are we convinced that even those processes which we have already regarded as explicable by chemical and physical laws, are in reality infinitely more complex, and at present defy any attempt at a mechanical explanation."

Dr. J. S. Haldane goes even further: "If we look back at the phenomena which are capable of being stated, or

the bath, as the Germans say, and ignore the most salient fact, that all the manifold processes are somehow correlated and centralized in a unified behavior and in purpose-like agency. Even the simplest organism is a higher unity than a whirlpool or a nebula in being a creative individuality.

From the Physicist's Point of View.—From the physicist's point of view, the living organism resembles, as we have already said, some wonderful kind of engine. It is a material system adapted to transform matter and energy, but it differs from any man-made machine in its greater efficiency, and in this, that the transfer of energy into it is attended with effects conducive to further transfer and retardative of dissipation, and in this, that it is a self-stoking, self-repairing, self-preservative, self-adjusting, self-increasing, self-reproducing engine. A linotype type-setting machine, for in-

explained in physico-chemical terms, we see at once that there is nothing in them characteristic of life. . . . We are now far more definitely aware of the obstacles to any advance in this (physico-chemical) direction, and there is not the slightest indication that they will be removed, but rather that with further increase of knowledge, and more refined methods of physical and chemical investigation, they will only appear more and more difficult to surmount." These two quotations illustrate the modern vitalist position, in its critical, non-constructive aspect at least. See Essay by J. Arthur Thomson and Patrick Geddes in "Ideals of Science and Faith," edited by J. E. Hand; Allen, London, 1905, p. 333 (pp. 49–80).

stance, is a most marvellous contrivance, but, after all, it does not grow from a piece of iron, though there is not much more in it, and it does not give rise to other linotype machines. In many ways, however, the living creature is like a machine, and when we think of the resemblances we should always remember that a machine is hardly a fair sample of the inorganic world, since in addition to the forces of the inorganic world it has inside of it a human thought. It is a materialized human idea, just as a picture is.

The time may come—who shall say—when we shall see the phenomena of organic life in better line with those of the inanimate world, but at present it is idle to deny that the activities of living creatures are things apart. Certain physical phenomena of surface-tension, of diffusion, of elasticity, of hydrostatics, of thermodynamics, of electricity, are detected, but not even the simplest vital activity can be completely redescribed in terms of physical formulæ. Even the passage of digested food from the alimentary canal to the blood-vessels is more than ordinary physical osmosis; it is modified by the fact that the cells are living. When we add up the components revealed by chemical and physical analysis, they do not amount to the whole resultant.

From the Biologist's Point of View.—(*a*) *Growth.* Leaving the chemical and physical standpoint, we

note from the biologist's point of view that the living organism *grows* after a fashion all its own, not as a rolling snowball grows by mere accretion, but by a unifying incorporation; not even as a crystal grows, at the expense of dissolved material chemically the same as itself, but at the expense of material quite different from itself. The grass grows at the expense of air, water, and salts, which, with the sun's aid, it lifts into the circle of life; and at the expense of the grass—after a period of maternal gastric education—the foal grows into a horse. It should be remembered, however, that the growth of crystals and the growth of certain minerals is no mere increase in bulk, but is, like organic growth, *an integration*, and results in forms of often startling beauty.

(*b*) *Cyclical Development*. Another familiar characteristic of living things is their cyclical development. From a microscopic egg-cell a seed develops, from the seed a seedling, from the seedling a beanstalk. "By insensible steps, the plant builds itself up into a large and various fabric of root, stem, leaves, flowers, and fruit, every one moulded within and without in accordance with an extremely complex, but, at the same time, minutely defined pattern. In each of these complicated structures, as in their smallest constituents, there is an immanent energy, which, in harmony with that resident in all the others, in-

cessantly works toward the maintenance of the whole and efficient performance of the part it has to play in the economy of nature. But no sooner has the edifice, reared with such exact elaboration, attained completeness, than it begins to crumble. By degrees, the plant withers and disappears from view, leaving behind more or few apparently inert and simple bodies, just like the bean from which it sprang; and like it endowed with the potentiality of giving rise to a similar cycle of manifestations."[1] It is a "Sisyphæan process, in the course of which the living and growing plant passes from the relative simplicity and latent potentiality of the seed to the full epiphany of a highly differentiated type, thence to fall back to simplicity and potentiality."[2]

So it is among animals. The microscopic germ-cell divides and redivides, differentiates and integrates into an embryo, the embryo may become a larva, which undergoes metamorphosis and becomes adolescent, or the embryo may steadily grow into a miniature of the mature organism. Sooner or later, in any case, the adolescent becomes the adult. But when this ascent from a *vita minima* at the beginning has reached the *vita maxima* of the full-grown organism, there begins to be a reversal of the process. A limit of growth is reached, reproduction occurs, and reproduction is often the

[1] Huxley, "Evolution and Ethics," 1893.

[2] Huxley, *loc. cit.*

beginning of death. The wear and tear of daily life is not perfectly compensated for, physiological arrears accumulate, the creature gets into debt, and there is a quick or slow descent to the *vita minima* of senescence, ending in natural death, if violent death has not previously intervened. We can make curves representative of the various kinds of life-history, some with a very rapid ascent and a slow descent, some with a slow ascent and a very rapid descent, some with a long period of maturity, some, as of the May-flies, with an almost abrupt apex. But always there is the same general phenomenon of cyclical development. For the life of the organism is very different from the path of a rocket in the air, returning spent to the level whence it rose, very different from the course of the drops of water in a fountain, which rise to the summit, sparkle a moment in the sunlight, and sink again to earth. The fact of reproduction makes an essential difference. In all but the simplest organisms, part of the growing germ gives rise to the body, but part remains unaltered and forms the germ-cells for another generation. The body perishes, but the germ-cells live on. Individual organisms are pendants that fall off an immortal lineage of germ-cells. Huxley compared the state of affairs to what might occur if a strawberry plant had an endlessly growing "sucker" or stolon, rooting here and there, and forming transient straw-

berry plants, but itself always pushing on, undying.

Of all vital phenomena, except those of evolution itself, and those wrapped up with intelligence, the processes of individual development are the most impressive in relation to the question of mechanistic and vitalistic interpretation.[1] The physiology of development is still in its infancy, and we shall doubtless be able in the future to understand better how one stage leads to another, but at present the whole process, so obviously continuous, is mysterious and baffling. We cannot picture how the hereditary qualities—maternal, paternal, and ancestral—lie *in potentia* in the microscopic fertilized egg-cell; we know very little regarding the stimulus that sets the process agoing, though Professor Loeb's striking experiments on artificial parthenogenesis are beginning to throw some light on the problem; we do not understand the orderly, correlated, regulated succession of events which leads from apparent simplicity to obvious complexity. We do not wonder at Sir Thomas Browne writing in his "Religio Medici": "Those strange and mystical transmigrations that I have observed in silk-worms turned my philosophy into divinity. There is in these works of nature, which seem to puzzle reason, something divine;

[1] See Hans Driesch, "The Science and Philosophy of the Organism," London, 1908.

and hath more in it than the eye of a common spectator doth discover." We do not wonder at Dr. Hans Driesch, one of the foremost and certainly the most philosophical of experimental embryologists, entitling one of his books, "The Soul as a Factor in Nature."

(*c*) *Effective Response.* Furthermore, the living organism is characterized by its power of effective response. There is response also in the inanimate, the bar of iron responds to heat, its particles have a quicker motion, and it expands; it responds likewise to the moist air and rusts, turning into oxide of iron. The barrel of gunpowder certainly responds to the spark, it explodes, destroying itself as gunpowder in so doing. But the responses of the living creature in normal surroundings are *effective*, they are self-preservative, they usually make for betterment. There is wastage, of course; there can be no activity without that; but the organism has a remarkable power of retaining its integrity, for days or years. We throw a piece of potassium on the basin of water, and it rushes about fizzing and flaring like a thing possessed, but in a minute all its activity is over. It goes out. On the other hand, we watch the movements of the whirligig beetle on the pool; it darts like a little water-sprite here, there, and everywhere over the surface, but, unlike the potassium pill, it does not go out. When it is tired, it takes a rest, and so it

goes on for weeks and months, and, if it gets big rests, for years. When its energies flag, it feeds, and recuperates itself. When danger threatens, it seeks its hiding-place. Its life is full of effective responses, and not the least important or marvellous is the power of taking a rest.

(*d*) *Unified Behavior.* This naturally leads on to a recognition of the general fact that the living creature has a unified activity, which is usually worthy of being called *behavior*. In his "Crayfish"—one of the best introductions to the study of zoology—Huxley compared the organism to a whirlpool, such as one may see below the Niagara Falls, which is always changing and yet always remaining the same. Amid ceaseless flux it retains a remarkable sameness. And truly, the living organism is like a whirlpool—a system within a system; streams of matter and energy are continually passing in and as continually passing out; and yet the unity persists. But the comparison does not sufficiently bring out what is so essentially characteristic of the organism, that all its changes are correlated in such a way that persistent unified behavior is in most cases possible.

Our familiarity with plant organisms may raise a difficulty, for their whole life seems rounded with a sleep. Plants are continually converting the kinetic energy of the sunlight into the potential energy of complex stored products, while animals

characteristically change potential energy into kinetic energy in locomotion and external work. Plants show a relative preponderance of constructive, upbuilding processes, and are hampered by the abundance of their riches. From another point of view, they are inhibited by their own internal waste-products, and slumber like hibernating animals, or like a fire too carefully banked up, half-smothered in its own ashes. But we probably under-appreciate the vegetative life. Although the lilies of the field neither toil nor spin, they are intensely active internally. Although plants do not walk about, many of them swim about. Young shoots move round in leisurely circles; the rootlets twist away from sharp edges, and on a piece of smoked glass they may be got to keep a diary of their daily movements; twining stems and tendrils bend and bow to the different points of the compass as they climb; leaves rise and sink, flowers open and close with the growing and waning light of day. In a large number of plants undeniable sense-organs are now known. Tendrils twine around the lightest threads, the leaves of the sensitive plant respond to a gentle touch, the tentacles of the sundew, the hairs of the fly-trap, the stamens of the rock-rose, the stigma of the musk, compare well with the sensitive and motile organs of many animals. They have some power, too, of profiting by experience. It is not

unjustifiable to speak of the Venus Fly-trap as having a short memory.

We used to think, as many still think, of the activities of the simplest animals or Protozoa, in a somewhat dull way, translating them all into mere reflexes or tropisms. And no doubt there are reflexes or tropisms, and this mode of interpretation must be pushed as far as it will go. But not further. For the careful work of Jennings, for instance, has shown us that these humble creatures sometimes exhibit what may be called the first hints of mind, at any rate, a pursuance of the method of trial and error. There is a selective behavior, such as we are ourselves continually exhibiting. The meaning of the term selective behavior may be illustrated by the story of a dog which was asked to carry a walking-stick with a crooked handle through a fence with close upright bars. It took the stick by the middle and jammed; it tried again, but began at the wrong end of the stick and jammed again. Finally, it gripped the handle in its mouth and ran triumphantly through. Similarly, Darwin found that the earthworms dealt in an effective way with the bifoliar spurs of the Scotch fir, and even with strange leaves of which they could have had no experience. Similarly, Jennings has found that some infusorians try one reaction after another, and select the one which is fit.

There seems a great deal to be said for the view that many of the activities in animals which we call mere reflexes, are, as it were, the degraded stages of activities which were to begin with self-determined or purposive—profitably degraded, for the agent thus becomes freer to solve new problems. In so saying, however, we need not return to the old and probably quite erroneous theory that "instincts" arose from "lapsed intelligence," which is a separate question. In any case we may agree that even simple actions of simple creatures illustrate what we must call unified behavior, which is effective and adaptive, directed by the creature itself. Even spermatozoa always swim against the stream. A self-acting, self-regulating, self-adjusting, self-preserving machine is no longer a machine. As a unity the organism lives, as a unity it develops, as a unity it evolves.

We may refer here to the important discussion of the whole subject of organisms and their evolution, which is given by Professor Bergson in his illuminating book, "L'Évolution Créatrice." He points out that one of the reasons why we boggle so much over the puzzle of life is that our intelligence is most at home among mechanical things—solids and their movements. It was trained in this school long before there was any philosophical biology. The organism bursts the categories of

"mechanical causality" and the like which we try to force upon it.

Our own mental experience, which we know best, means continual change; from day to day we ripe and ripe; we are continually recreating ourselves, artists of our own life. So the organism has true experience and history, which a stone never has; there is persistence in spite of ceaseless change; there is a continual registration of the results of time, and there is continual creation. The organism's creativeness is incalculable, unpredictable; it uses time so as to profit by experience; it is continually making itself afresh. In its essential features it thus transcends mechanical description.

Origin of Organisms upon the Earth.—No one doubts that at some uncertain, but inconceivably distant date, living creatures appeared upon the earth, which had previously been tenantless. During the early phases of the earth's history, before it cooled and consolidated, the conditions were quite impossible for such organisms as we know, and there is no use talking about any other. The question is: What was the manner of the becoming of living creatures upon the earth; and the answer is that we do not know. Our inquiry might close at this point, were it not that a number of less truthful answers have been given, were it not that a discussion of the subject may enable us to bring into greater prominence the essential

insignia of livingness. Some apprehension or appreciation of these always colors our picture of Nature, though the dominant tone always depends on what we make of man himself. Let us first take a brief historical survey. Perhaps it is well to speak of the problem as the origin of living organisms, rather than of life. Life is an ambiguous and mysterious term. We do not know what life in its essence really implies. We may be begging the question in asking how "life" began. Life may be a particular mode of motion as old as other modes of motion—such as heat or elasticity or matter. Or "life" may be in its essence inseparable from what we call "spirit." Therefore, to inquire into the origin of life may be like inquiring into the origin of motion or the origin of consciousness. But it is still too soon to say so.

Various Suggestions.—The first possible answer is that living organisms began after a fashion which we can never form any scientific conception of, that the origin of life is for science a quite insoluble problem. This answer saves a lot of trouble, but the objection to it is that it is prematurely dogmatic, closing the door on legitimate scientific inquiry.

Secondly, Preyer and others have suggested that germs of life, confessedly unlike any we now know, may have existed from the beginning even in nebulous masses. It was not, indeed, the pro-

toplasm we know that was encradled in the fire-mist; it was a kind of movement, a particular dance of corpuscles, different in its measures from inorganic dances. But there does not seem much utility in discussing a hypothetical kind of organism which could live in nebulæ; our conception of organic life must be based on the organisms we know. It is interesting, however, to note that Preyer strongly opposed the view that organic substance could arise or could have arisen from inorganic substance; the reverse supposition seemed to him more tenable.

As a corollary of the second answer we may notice the view that organisms came to the earth from elsewhere.

As far back as 1865, H. E. Richter started the idea that germs of life are continually being thrown off from the heavenly bodies, and that some of these found lodgment on the earth, when it was ready for them. For him, as for Preyer, it was impossible to think of life beginning; his dictum was, *Omne vivum ab æternitate e cellula.* To Helmholtz (1884) and to Sir William Thomson (Lord Kelvin) the same idea occurred, that germs of life may have come to the earth embosomed in meteorites. "I cannot contend," Helmholtz said, "against one who would regard this hypothesis as highly or wholly improbable. But it appears to me to be a wholly correct scientific pro-

cedure, when all our endeavors to produce organisms out of lifeless substance are thwarted, to question whether, after all, life has ever arisen, whether it may not be even as old as matter, and whether its germs, passed from one world to another, may not have developed where they found favorable soil. . . . The true alternative is evident: organic life has either begun to exist at some one time, or has existed from eternity." On the other hand, we may note that the word "eternal" is somewhat irrelevant in scientific discourse, that the notion of such complex substances as proteids (essentially involved in every organism we know) being primitive, is quite against the tenor of modern theories of inorganic evolution; and that, though we cannot deny the *possibility*, it is difficult to conceive of anything like the protoplasm we know surviving transport in a meteorite through the intense cold in space and through intense heat when passing through our atmosphere. The milder form of the hypothesis associated with the name of Lord Kelvin was simply one of transport; he wisely said nothing about "eternal cells" or any such thing; he simply shifted the responsibility of the problem of the origin of living organisms off the shoulders of our planet.

Spontaneous Generation.—Apart from the abandonment of the problem as scientifically insoluble —apart, that is to say, from the view that living

creatures began to be in some way which we cannot hope to formulate in terms of the scientific "universe of discourse," we have the suggestions (*a*) that the physical basis of life is as old as the cosmos, and (*b*) that germs of organisms may have come from elsewhere to our earth. There is but one other possible view, namely, that what we call living evolved in Nature's laboratory from what we call not-living—a view to which the trend of evolutionist thinking certainly attracts us. There are few living biologists[1] who doubt the present universality of the induction from all sufficiently careful experiment and observation—*omne vivum e vivo;* but it is quite another thing to say that abiogenesis may not have occurred in the past or may not occur in the future. The dictum *omne vivum e vivo* is a statement of empirical fact; it is not a dogmatic closing of the question.

It is perhaps useful, at this stage, to remember that the idea of the origin of the living from the not living is very old, and has persisted for at least twenty centuries. A belief in spontaneous generation was held at dates as widely separated as are suggested by the names of Aristotle, Augustine, Lucretius, Luther, Francis Bacon, and Harvey.

[1] Dr. Bastian is practically alone in believing that creatures like Infusorians and Amœbæ (highly complex individualities in their own way) can now arise from notliving material.

The belief rested on misinterpretations not unnatural at times when microbes were unknown, or when the life-histories of common parasites were very dimly discerned, or when no one dreamed of the minuteness and ready transportability of the germs of even worms. It was supposed that thistles arose *de novo* from the dust, that bees sprang from dead oxen, that frogs were engendered from the mud.

But though many thoughtful biologists, such as Huxley and Spencer, Nägeli and Haeckel, have accepted the hypothesis that living organisms of a very simple sort were originally evolved from not-living material, they have done so rather in their faith in a continuous natural evolution, than from any apprehension of the possible sequences which might lead up to such a remarkable result. The hypothesis of abiogenesis may be suggested on *a priori* grounds, but few have ventured to offer any concrete indication of how the process might conceivably come about. To postulate abiogenesis as if it were a matter of course betrays an extraordinarily easy-going scientific mood.

Some Concrete Suggestions.—One of the few concrete suggestions is due to the physiologist Pflüger (1875), whose views are clearly summarized in Verworn's "General Physiology." Pflüger suggested that it is the cyanogen radical (CN) which gives the "living" proteid molecule its character-

istic properties of self-decomposition and reconstruction. He indicated the similarities between cyanic acid (HCNO)—a product of the oxidation of cyanogen—and proteid material, which is admitted to be an essential part, at least, of all living matter. "This similarity is so great," he said, "that I might term cyanic acid a half-living molecule." As cyanogen and its compounds arise in an incandescent heat when the necessary nitrogenous compounds are present, they may have been formed when the earth was still an incandescent ball. "If now we consider the immeasurably long time during which the cooling of the earth's surface dragged itself slowly along, cyanogen and the compounds that contain cyanogen- and hydrocarbon-substances had time and opportunity to indulge extensively in their great tendency toward transformation and polymerization, and to pass over with the aid of oxygen, and later of water and salts, into that self-destructive proteid, living matter."[1]

Verworn adopts and elaborates this suggestion: Compounds of cyanogen were formed while the earth was still incandescent; with their property of ready decomposition they were forced into correlation with various other compounds likewise due to the great heat; when water was precipitated

[1] Quoted by Verworn, "General Physiology" (1899), p. 307.

as liquid upon the earth these compounds entered into chemical relations with the water and its dissolved salts and gases, and thus originated extremely labile, very simple, undifferentiated living substance.

Professor E. Ray Lankester, in his article, "Protozoa," in the "Encyclopædia Britannica," makes the suggestion, "that a vast amount of albuminoids and other such compounds had been brought into existence by those processes which culminated in the development of the first protoplasm, and it seems therefore likely enough that the first protoplasm fed upon these antecedent steps in its own evolution."

Dr. H. Charlton Bastian suggests, in regard to the *first* origin of living matter upon the earth, that the nitrate of ammonia which is known to be produced in the air during thunder-storms, and is discovered in the thunder-shower, may have played an important part in the mixture of ingredients from which the hypothetical natural synthesis of living matter was effected.

Mr. J. Butler Burke postulates original vital units or "bio-elements," which "may have existed throughout the universe for an almost indefinite time," which are probably "elements possessing many of the chemical properties of carbon and the radio-active properties of the more unstable elements," and which, by interacting on otherwise

present carbon-compounds, probably gave rise to cellular life as we know it to-day.

By allowing quantities of radium salt to act on sterilized bouillon, Mr. J. Butler Burke obtained transient little bodies which he called "radiobes," which seemed to him on the border-line between the animate and the inanimate. Mr. Burke did not claim, however, to have effected "spontaneous generation." To expect to make a full-blown bacillus at the present day, he says, would not be less absurd than to try to manufacture a man. He admitted that his "radiobes," which are soluble in water, are "altogether outside the beaten track of living things," though he maintained that they have $n—1$ of the n properties of the living organism. "That little more and how much it is, That little less and what worlds away." It should be remembered, too, that this investigator postulates a potential vitality, and indeed spirituality, in all matter. Matter, he says, is ultimately mind-stuff, and the atoms are nothing more than ideas.

Difficulty of the Problem.—It must be admitted that, in spite of these and other concrete suggestions, we are still far from being able to imagine how living matter could arise from not-living matter. But we must remember that many things happen which we do not understand. Two substances combine to form a new substance with quite different properties, which are doubtless due

to what the component parts have contributed, though we do not know *how*. At the same time in postulating possible processes which may have occurred long ago in Nature's laboratory, it is always desirable that we should be able to back these up with evidence of analogous processes now occurring in Nature—the usual mode of argument in evolutionist discourse—but these analogues are not forthcoming at present. It is usual to refer to the achievements of the synthetic chemist, who can now manufacture artificially such natural organic products as urea, alcohol, grape sugar, indigo, oxalic acid, tartaric acid, salicylic acid, and caffeine. But four facts should be borne in mind: (1) the directive agency of the intelligent chemist is an essential factor in these syntheses; (2) no one supposes that a living organism makes its organic compounds in the way in which many of these can be made in the chemical laboratory; (3) no one has yet come near the artificial synthesis of proteids, which are the most characteristic substances in living matter; and (4) there is a great gap between making organic matter and making an organism. When Kekulé spoke of looking forward to the time when we shall "build up the formative elements of living organisms" in the laboratory, he probably had the distinction between the organism and its several component substances quite clearly in mind.

We are in the habit of comparing what man can do in the way of evolving domesticated animals and cultivated plants with what we believe Nature has done in the distant past. Why, then, should we not argue from what the intelligent chemist can do in the way of evolving carbon-compounds to what Nature may have done before there was anything animate? There is this difference, among others, in the two cases, that in the former we can actually observe the operation of natural selection which in Nature takes the place of the breeder, while we are at a loss to suggest what, in Nature's as yet very hypothetical laboratory of chemical synthesis, could take the place of the directive chemist.

Thus Professor F. R. Japp, following Pasteur, pointed out in a memorable British Association address that natural organic compounds are "optically active" (a characteristic property which cannot be here discussed), that artificially prepared organic compounds are primarily "optically inactive," that by a selective process the intelligent operator can obtain the former from the latter, *but* . . . it is difficult to conceive of any mechanism in nature which could effect this. "No fortuitous concourse of atoms, even with all eternity for them to clash and combine in, could compass this feat of the formation of the first optically active organic compound." "The chance syn-

thesis of the simplest optically active compound from inorganic materials is absolutely inconceivable."

Not content, however, with indicating the difficulty which the believer in abiogenesis has here to face, Professor Japp went on to say—perhaps, in so doing, leaving the rigidly scientific position: "I see no escape from the conclusion that, at the moment when life first arose, a directive force came into play—a force of precisely the same character as that which enables the intelligent operator, by the exercise of his will, to select out one crystallized enantiomorph and reject its asymmetric opposite." After prolonged discussion, and in view of various suggestions of *possible* origins, he wrote: "Although I no longer venture to speak of the *inconceivability* of any mechanical explanation of the production of *single optically active compounds asymmetric always in the same sense,* I am as convinced as ever of the *enormous improbability* of any such production under chance conditions."

Apart, then, from the fact that the synthesis of proteids seems still far off, apart also from the fact that there is a great gap between a drop of proteid and the simplest organism, we have perhaps said enough to show that the hypothesis of abiogenesis is not to be held with an easy mind, attracted as we may be to it by the general evolutionist argument.

Apartness of Living Creatures.—In thinking over this difficult question there are two cautions which should be borne in mind. We must not exaggerate the apartness of the animate from the inanimate, nor must we depreciate it. On the one hand, we must recognize that modern progress in chemistry and physics has given us a much more "vital" conception of what has been libelled as "dead matter"; we must not belittle the powers of growth and regrowth which we observe in crystals, the series of form-changes through which many inorganic things, even drops of water, may pass; the behavior of ferments; the intricate internal activity of even the dust. When we consider, too, such phenomena as "latent life," and "local life," and the relatively great simplicity of many forms and kinds of life, we do not find it easy to discover absolute, universal, and invariable criteria to distinguish between animate and inanimate systems, or between the quick and the dead. To some extent, also, the artificial synthesis of complex organic compounds, and the ingenious construction of "artificial cells" which closely mimic the structure of living cells, though no one supposes that they are in the faintest degree "alive," serve to lessen the gap which seems at first so wide.

There is certainly some interest in the artificial foam-cells of Quincke and Bütschli, in Dubois' "vacuolids" or "eobes," in Butler Burke's "radi-

obes," in Sir William Ramsay's Helium cells, in Lehmann's liquid crystals, and in the wonderful crystallization phenomena described by von Schrön. One of the latest of the courageous essays bearing on experimental biogenesis (M. Kuckuck's "Lösung des Problems der Urzeugung," 1907), points out that if we add Barium chloride, or a salt of Radium, or a salt of Nuclein, to a gelatine-peptone-asparagin-glycerine-sea-water mixture, we may get little corpuscles which feed, grow, segment, move, and, in fact, do most things except *live*.

It is gratuitous to suppose that experiments along these lines may not help us to get on the track of Nature's synthesis, or that they may not have important practical results. It should be remembered too that while we have no experimental reason for saying that we *can* make an organism artificially, we have no experimental reason for saying that we *cannot*. We have no way of proving the impossibility of an occurrence that is not a contradiction in terms.

On the other hand, it is the verdict of common sense and exact science alike that living creatures stand apart from inanimate systems. In the inanimate world we find order, but no self-adjusting adaptation; response to stimulus, but no effective self-preservative response; struggle but no struggle for existence; change but no creative agency.

The living creature feeds and grows; it undergoes ceaseless change, yet has a marvellous power of retaining its integrity; it is not merely a self-stoking, self-repairing engine, but a self-reproducing engine; it has a self-regulative development; it gives effective response to external stimuli; it profits by experience; it *uses* time; it coördinates its activities into unified behavior, it may be into intelligent deeds and rational conduct. Allowing for the gradual realization of potentialities in the course of evolution, we cannot but feel that if the living emerged from the not-living, then our appreciation of not-living matter must be greatly enhanced. As a matter of fact, however, we cannot at present redescribe any vital behavior in terms of physical and chemical categories, and the secret of the organism has to be admitted as such whether we advance to a vitalistic statement of it or not. In vitalistic doctrine we must distinguish two positions, first, the negative statement, which seems at present safe, that no vital activity can be completely redescribed in terms of physics and chemistry, and second, the positive statement, which is open to various objections, that there is in the living creature some "vital principle" or "Entelechy."

If an Organism Could be Made Artificially, What Then?—Finally, let us suppose that some bold experimenter in the borderland between chemistry

and biology, a man like Professor Jacques Loeb, is successful this year or next year in making, not merely a corpuscle of proteid, but a little living thing, by some ingenious synthesis. What then?

(*a*) It is quite likely that the steps leading to this hypothetical achievement might be as unlike those which, on the hypothesis of abiogenesis, once occurred in Nature's laboratory, as the artificial synthesis of, say, oxalic acid is unlike what takes place in the sorrel in the wood. (*b*) At present we cannot assert that the laws of the movements of organic corpuscles can be deduced from the laws of motion of not-living corpuscles—continuous as we may believe cosmic evolution to have been—and the artificial production of a living creature would not enable us to make this assertion. What simplification of descriptive formulæ the future has in store for us no one can predict. We may have to simplify the conceptual formulæ which we use in describing animate behavior, and we may have to modify the conceptual formulæ which we use in describing inanimate sequences, but at present the two sets of formulæ remain distinct, and they would so remain even if a little living creature were manufactured to-morrow. (*c*) If we discovered a method of artificially producing an organism, as Loeb has discovered a method of inducing an egg to develop without fertilization, it would render the hypothesis of abiogenesis more

credible. We would then *know*, what no naturalist at present knows, however strongly he may believe it, that what we call not-living has in it the potentiality of giving origin to what we call living. But the hypothetical discovery would in no way affect the dignity and value of living creatures, or of our own life. The whole world would be more continuous and vital. (*d*) If it came about that we were able to bring materials and energies together in such a way that living creatures of a simple sort resulted, we should still have to remember that *we* had acted as directive agents in the synthesis. (*e*) Finally, if the experiment succeeded, we should not have arrived at any *explanation* of life. We should be able to say that, given certain antecedent conditions, certain consequences ensue, but we should still be unable to answer the question *how* or *why*. We should have a genetic description of an occurrence, but no explanation of it. For that is what science never supplies.[1]

In conclusion, to quote Principal Lloyd Morgan, "Those who would concentrate the mystery of existence on the pin-point of the genesis of proto-

[1] The intellectual outcome of the long-drawn-out discussion on the origin of living organisms is certainly disappointing, but it is interesting to notice that it has been richly rewarded in practice. It has led to discoveries in the preservation and improvement of food, to an entirely new view of parasites, to the use of antiseptics, and to the cure of many diseases.

plasm, do violence alike to philosophy and to religion. Those who would single out from among the multitudinous differentiations of an evolving universe this alone for special interposition, would seem to do little honor to the Divinity they profess to serve. Theodore Parker gave expression to a broader and more reverent theology when he said: "The universe, broad and deep and high, is a handful of dust which God enchants. He is the mysterious magic which possesses," not protoplasm merely, but "the world."

This is all very well, some one may say, but are you not at least leading us to look with some favor on what is a materialistic view of life? If this be the impression left, then our statement has failed of its purpose. Materialism is the theory that there is nothing real in the universe except redistributions of matter and energy in the ether. To which it may be answered—first, that matter, energy, ether, are simply conceptual formulæ of science, corresponding to a reality which we cannot get at, but which we get nearest when we know it in ourselves as thought; and secondly, that no juggling with these concepts can possibly account for even the materialistic philosophy.

"There can be little doubt," Huxley said, "that the further science advances, the more extensively and consistently will all the phenomena be represented by materialistic formulæ and symbols."

"But the man of science, who, forgetting the limits of philosophical inquiry, slides from these formulæ and symbols into what is commonly understood by materialism, seems to me to place himself on a level with the mathematician who should mistake the x's and y's with which he works his problems for real entities; and with this further disadvantage as compared with the mathematician that the blunders of the latter are of no practical consequence, while the errors of systematic materialism may paralyze the energies and destroy the beauty of life."

As Prof. Karl Pearson puts it in his "Grammar of Science": "The problem of whether life is or is not a mechanism, is not a question of whether the same things, 'matter' and 'force,' are or are not at the back of organic and inorganic phenomena—of what is at the back of either class of sense-impressions we know absolutely nothing—but of whether the conceptual shorthand of the physicist, this ideal world of ether, atom, and molecule, will or will not also suffice to describe the biologist's perceptions."

Those who may be inclined to dissent from the view that Science deals merely with "counters;" which are representative of reality, may be reminded that even in the psychical realm we do the same. Thus Berkeley affirms over and over again that no idea can be formed of a soul or spirit.

"The words *will, soul, spirit,* do not stand for different ideas, or in truth, for any idea at all, but for something which is very different from ideas, and which, being an agent, cannot be like unto or represented by any idea whatever." And similarly, to go to the other pole, namely, scientific psychology, we find one of its ablest exponents, Professor Münsterberg, admitting that it "is not an expression of reality, but a complicated transformation of it, worked out for special logical purposes in the service of our life." ("Psychology and Life," 1899.)

Fundamental Mysteriousness of Nature.—Let us put the matter in another way by asking whether Science has any contribution to make toward a recognition of the spirituality of Nature. At first, of course, Science draws in its horns and says NO. That is not its *métier.* But it is better than its word, for it discloses Rationality, Order, Unity, Progress; and that is great gain. It also recognizes the fundamental mysteriousness of Nature, and that in three ways. There is mysteriousness in the common denominator—say, Matter, Energy, Ether—to which it seeks to reduce things. There is mysteriousness in the sequences it discloses, when the resultant consequences are new as compared with their component antecedents. There is mysteriousness in the beginnings from which it starts in its genetic descriptions; they do

not suggest what is to come out of them any more than an egg suggests a bird.

Fortuitousness.—The general trend of evolutionary thinking and speculation inclines us to entertain the belief that the living may have emerged from the not-living in ages long since past. If so, we may be sure that it did not emerge by chance, but was as rigorously predetermined as the origin of the solar system from a swarm of meteorites. Lord Kelvin made himself responsible for the statement, that while "fortuitous concourse of atoms" is not an inappropriate description of the formation of a crystal, it is utterly absurd in respect to the coming into existence, or the growth, or the continuation, of the molecular combinations presented in the bodies of living things.[1] One agrees with the latter part of the statement, but one finds it difficult to entertain the first. What does a "fortuitous concourse of atoms" mean, unless simply a concourse whose antecedent conditions are unknown to us? It cannot mean a chaotic state of things, if it gives rise to one of the most beautiful of cosmic units—a crystal.

In Conclusion.—If we see any good reason for

[1] Which, he went on to say, compel us to conclude that there is scientific reason for believing in the existence of a creative and directive power. See Professor Ray Lankester's Letter to the *Times*, May 17, 1903, and his "Kingdom of Man," 1907, p. 62.

believing in the erstwhile origin of the living from the not-living, we give a greater continuity to the course of events, and we must again read something into the common denominator of science—Matter, Energy, and the Ether. We have already read into this, Wonder and Mystery, Harmony and Order, and we must now read into it—Progress and, from a philosophical standpoint, Purpose. Unless Increase of Complexity and Integration, Harmony and Beauty, be considered *Ends* justifying themselves, we cannot read the Riddle of the Earth considered by itself. If, however, the dust of the earth did naturally give rise to living creatures, if they are in a real sense her children, then we understand better all the groaning and travailing, and what seemed only a development becomes an *evolution*.

IV

THE EVOLUTION OF ORGANISMS

IV

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The General Idea of Evolution.—In human affairs what seems to the careless to be quite novel is often revealed to the careful student as the natural outcome of processes which have their origin in antiquity. We see the gradual growth of social organizations, the natural transition from one established order of things to another slightly different position of temporary equilibrium, the transformation of one institution into another, and—apart from any philosophy of history—we sum up what we observe in the general concept of social evolution. It was, indeed, in relation to human affairs that the evolution-formula first became a useful organon, and it is an oft-told tale how it was gradually applied to the heavens above and to the earth beneath and to animate nature in general.[1] Thence, improved by the using, the formula has returned for reapplication to human history. Now, although there are noteworthy differences between the making of the solar system, the differentiation of the earth, the evolution

[1] See the author's "Progress of Science."

of living creatures, and the history of societary forms, all cases have this in common, that a process of Becoming leads to a new phase of Being. The study of evolution is a study of *Werden* and *Vergehen* and *Weiter-Werden.* The general idea of evolution is, that the present is the child of the past and the parent of the future.

The evolution-idea is probably as old as clear thinking, which we may date from the (unknown) time when man discovered the year—with its marvellous object-lesson of recurrent sequences—and realized that his race had a history. Whatever may have been its origin, the idea—that the present is the child of a simpler past and the parent of a more complex future—was familiar to several of the ancient Greek philosophers, as it was to Hume and Kant; it fired the imagination of Lucretius and linked him to another poet of evolution—Goethe; it persisted, like a latent germ, through the centuries of other than scientific preoccupation; it was made actual by the pioneers of modern ætiology—men like Buffon, Lamarck, Erasmus Darwin, Treviranus, and Etienne Geoffroy St. Hilaire—and it became current intellectual coin when Charles Darwin, Alfred Russel Wallace, Herbert Spencer, Haeckel, and Huxley, with united but varied achievements, won the conviction of the majority of thoughtful men. Since this achievement the fact of organic-evolution has

been taken for granted, and there has been a concentration of inquiry on the originative and directive factors in the mysterious process of organic becoming.[1]

Stated concretely, the general doctrine of descent or organic evolution suggests, as we all know, that the plants and animals now around us are the results of natural processes working throughout the ages, that the forms we see are the lineal descendants of ancestors on the whole somewhat simpler, that these are descended from yet simpler forms, and so on backward, till we lose our clue in the unknown—but doubtless momentous—vital events of pre-Cambrian ages, or, in other words, in the thick mist of life's beginnings.

Why do we accept this modal interpretation? The view that things have always been as they are is demonstrably false; the theory of successive cataclysms and subsequent recommencements is hardly thinkable; the only available scientific formulation is the theory of descent. We accept it because it fits the facts we know, because no facts contradict it, because it is congruent with our interpretation of other orders of facts. We cannot verify it as we can verify the indestructibility of matter, the conservation of energy, or the formula of gravitation, but we do know that there is a

[1] See the author's "Study of Animal Life" and "The Science of Life."

certain amount of evolution going on under our eyes, and that not confined to Mr. Burbank's garden or the breeders' pens. We extend the idea to the past and find that it works well.

Every one knows how Darwin with sublime patience accumulated evidence of evolution (*a*) from the distribution of animals in space; (*b*) from their successive appearance in time; (*c*) from actual changes observed in domestication, cultivation, and in nature; (*d*) from facts of anatomical structure, such as homologous and vestigial organs, and (*e*) from the abbreviated recapitulation of the past which seems to occur in individual development. But magistral as his work was, it did not, and could not, demonstrate the doctrine of descent; it simply gave what one may call a cumulative justification by showing how well the formula fitted a vast series of facts. Thus the phrase "evidences of evolution," except as applied to what we actually see going on, is not altogether appropriate. Every differentiation and every adaptation of structure or of function may be interpreted as a product, and may thus become "an evidence of evolution."

Validity of Scientific Interpretation.—It is necessary at this point to interpolate a general consideration. The Theory of Descent tacitly makes the assumption—the basal hope of all biology—that it is not only legitimate but promiseful to try to interpret scientifically the history of life upon the

earth. If any one has good reason for believing that the long process of Becoming, which has eventually led to ourselves and our complex animate surroundings, is altogether too mysterious or too marvellous to admit of successful treatment by ordinary scientific methods, then he denies at the outset the validity of the evolution formula. There is no use going further. Here is the parting of the ways, and there is no *via media.* The facts of history as the rocks reveal them will remain, but the book is shut for science. The order of Nature remains, but it is no longer the order of scientific intelligibility.

If any one decides on *a priori* grounds that there is no hopefulness in attempting a scientific analysis of the confessedly vast and perplexing problem of genesis, then let him remain poet or artist, philosopher or theologian. There is no sense in niggling criticism if the scientific method is prejudged as invalid.

On the other hand, if the scientific attempt at formulating the steps in genesis is legitimate, and if it has made good progress, considering its youth, then let us rigidly exclude *from our science* all other than scientific interpretations; let us cease to juggle with words by attempting a mongrel mixture of scientific and transcendental formulation; let us stop trying to eke out demonstrable factors by assuming in the same breath alongside of these,

"ultra-scientific causes," "spiritual influxes," *et hoc genus omne;* let us cease writing or reading books with titles like "God or Natural Selection," whose initial false antinomy is sufficient index of their misunderstanding. Not, of course, that we are objecting for a moment to any metaphysical or theological interpretations whatsoever; we are simply stating the commonplace that it is unprofitable to try to talk two languages at once, that we cannot with sanity have scientific formulæ mixed up with transcendental formulæ in one sentence; and that to place these against one another is to oppose incommensurables and to display an ignorance of what the aim of science is. The great French physiologist Claude Bernard has written, "I am persuaded that the day will come when the physiologist, the poet, and the philosopher will speak the same language and will understand one another."[1] We feel sure about the second part of this prophecy, that there will be mutual understanding; but we cannot even hope for the day when physiologist, poet, and philosopher will speak the same language.

The Actual History as Disclosed by the Palæontologists.—Returning to the actual history of the forms of life—and of course the succession of

[1] "Je suis persuadé qu'un jour viendra où le physiologiste, le poète, et le philosophe parleront la même langle et s'entendront tous."

events remains whether we are scientific evolutionists or not—we find that the patience of the palæontologists has been gradually disclosing a majestic pageant, an age-long, ever-changing procession of faunas and floras across the stage of the earth. If we had a series of instantaneous daily photographs of all that has taken place since life began to be, a complete pictorial history of the past would be possible, and evolution would be verified. If even complete remains of past ages had been safely buried in great treasure houses, such as Frederic Harrison has proposed should henceforth be made for the enlightenment of posterity, then palæontology would be an easier business than it is. Then a genealogical tree connecting the Protist and Man would be possible, and we should have under our eyes what is now but a dream—a complete record of the past. As it is, we have to eke out our palæontology with hints from comparative anatomy and comparative embryology, which require to be used very carefully.

The fossil-containing rocks have often been compared to a library, with the oldest books on the lowest shelves, but what a library! Spoilt by fire by water, by earthquake, by decay, here half a shelf awanting and there a series of volumes with most disappointing gaps; pages out of books; words missing in sentences, and the vowels awanting like the points in Hebrew. We are troubled

also by palimpsests, one record on the top of another.

We cannot wonder at "the imperfection of the geological record," when we remember how young palæontology is, how young, for that matter, man is—his whole history but a tick of the geological clock; how many areas are still unexplored; how much ground—being covered by sea—must remain unknown. We cannot wonder that the materials of the history are scrappy when we understand that only hard organisms or hard parts are likely to be preserved, that only certain kinds of rocks are suitable tombs, and that many rocks have been unmade and remade many times over. As we walk along the shore and study the jetsam, we see how quickly many of the sea's memoranda are obliterated. The wonder really is that the record is as complete as it is, that from "the strange graveyards of the buried past" we can learn so much about the life that once was.

It is impossible to read even a little about the study of fossils without a thrill of admiration for the patience and insight of the biological archæologist. He tells us of fossil jellyfishes and of the young stages of Graptolites; he makes from fragmentary specimens a vivid reconstruction of a primitive Vertebrate not much over an inch in length; he makes the great dragons of the prime disport themselves before us; he counts the cuttlefish shells

in an Ichthyosaur's stomach and the embryos within the mother; he discovers ancient generalized types, like Phenacodus, uniting widely separate modern orders; he binds birds to reptiles (through the Deinosaurs) and flowering to flowerless plants (through the Pteridosperms); he tracks the transformations of the Ammonites, and works out the pedigree of the horse and the elephant.

General Impressions.—Looking back on the history which the palæontologists have with infinite patience disclosed, we cannot but be impressed by some general facts.

First of all, it is noteworthy that, as Whitman said, "everything is equally perfect." When we look at a series of human inventions, such as the historical gallery of microscopes at the Paris Exposition, or a chronological series of bicycles or locomotives, we feel at once that the early stages are crude and clumsy, showing the prentice hand. But this cannot be said of Nature's series. There is no crudity, no suggestion of the half-finished, about the early Graptolites, or Trilobites, about the Ammonites and Nautili, about the Ganoid fishes or the ancient Saurians.

Secondly, no one can think over the evolution of plants and animals without feeling that the fountain of life is practically inexhaustible. All idea of limitation or economy is irrelevant. There is a suggestion of infinite resource. We seem to be

in the presence of a great artist who litters his studio floor with priceless sketches. There is no suggestion of pursuing a direct path to some goal. Nature is full of elaborate circuitousness; there are numerous culs-de-sac. If we are to know God through His works, this must enter into our knowledge. We can understand what Tennyson meant when he said, lingering over the crowded life in the brook, "What an imagination God has."

Thirdly, it is undeniable that, in the course of the ages, many types have quite died out, leaving no lineal descendants at all. We visit ancient half-buried cities now the abode of bats and owls, or majestic deserted shrines still sublime in their loneliness, and there comes over us a feeling of awe with the thought that our race is so old that we can sometimes hardly tell what manner of men thronged the now silent streets, or worshipped in these empty shrines. But how is this feeling increased when we come to study the remains of races which have been wholly erased from the roll of life—lost races whose lineage has come absolutely to an end!

As Gaudry has said: "A host of creatures have vanished; the most powerful, the most fertile have not been spared. There is a sadness in the spectacle of so many inexplicable losses." He was referring, of course, not to extinct species, which are represented to-day by living descendants, but to

what we must call extinct types or lost races, such as the Graptolites and Trilobites, the Eurypterids and Pterodactyls. It is true that nothing is ever really lost in this economical world. No scientific student of what is called the circulation of matter can have failed to recognize the deep truth in the reincarnation of Buddha. The grass becomes the sheep, the sheep the tiger, the tiger grass again. Atoms that compose part of us may have formed part of a Deinosaur. "The dust of Cæsar, dead and turned to clay, may stop a hole to keep the wind away." Yet the physicists' consolation is wan and cold. The fact remains that those particular combinations of elements which we call lost races—those particular smiles of creative genius—have disappeared as such forever.

In most cases, as far as we can judge, the end came slowly, and not by catastrophes. Races waned and died out; they were not suddenly extinguished. Another striking fact is that while evidences of senescence have been detected in some of the last representatives of dwindling races, there are many cases where a full stop seems to have been put to the history of a stock while it was yet in its prime. Nor is there any reason to think of an elimination of weaklings. As Gaudry says: "While insignificant creatures persist, the primes of the animal world vanish—without return." The Ammonites ceased at the time of their finest de-

velopment; the sea-serpents and the monstrous terrestrial dragons were no weaklings when death gathered them; the flying reptiles, small during the Jurassic, attain large dimensions by the end of the Cretaceous, and then—pass away forever.

We cannot do much more than guess as to the conditions of the extinction of races. Sometimes, perhaps, there were changes of environment, to meet which the plasticity of the creatures was insufficient; sometimes, perhaps, the struggle for existence was to the death, as it may have been between cuttlefishes and trilobites, between Ichthyosaurs and Belemnites; sometimes, perhaps, there were constitutional defects, brought about by over-specialization or the like, such as Lucretius thought of when he pictured races going down to destruction, "hampered all in their own death-bringing shackles."

Sluggish sedentary creatures, walled within their castles of indolence, may have become, as it were, smothered in these. This is suggested by the extreme calcification of certain extinct types like the Cystoids and Blastoids. Others again, like the flying dragons, have perhaps lived too quickly for their constitutions, life's fitful fever proving too much for them. There seems, also, to be a risk involved in being gigantic or in being very highly specialized. As Marsh says, the Iguanodon

might have had for epitaph, "I and my race died of over-specialization."

The facts at any rate remain, and they must enter into our picture—our conception—of Nature. The idea of waste of beauty or fineness of structure is quite irrelevant.

> "'So careful of the type,' but no,
> From scarped cliff and quarried stone
> She cries, 'a thousand types are gone;
> I care for nothing, all shall go.'"

However we may try to explain it—which science never seeks to do—in relation to our often very anthropomorphic concepts of End and Purpose—the fact remains that Nature is, as we have said, continually painting out her picture, continually breaking her mould.

This, perhaps, was the meaning of that strange stanza in Emerson's "Song of Nature":

> "Twice I have moulded an image,
> And thrice outstretched my hand;
> Made one of day, and one of night
> And one of the salt sea-sand."

Perhaps we should infer that a thing of beauty, a smile of creative genius, is sufficient end in itself.[1]

[1] Speaking of lost races, warrants us in saying a word on a subject which is always near the heart of the lover of living creatures—we refer to the present-day extinction of

The strange facts as to the entire passing away of animal races, like the parallel facts in regard to particular human races, cannot fail to raise, and ought to raise, a question as to the endurance of our own modern races. It sends a chill to patriotic hearts to think of any human race passing wholly away, and yet such things have been. So far as a race goes on accumulating organic debts

types. Long ago life was like a great army always losing from its ranks, but yet always gaining new recruits. Now it seems as if it only loses. This may be partly due to the fact that careful scientific records extend over a very short time, but it is also due to our gross carelessness of life. We can breed a little, but we cannot any longer domesticate. There is some success with Bacteria, for we are breeding new species, and we are apparently learning to tame old ones. But the present point is our carelessness in elimination. On one occasion, some thirty years ago, no fewer than one hundred and four African elephants were destroyed in one great battue—a dismal butchery, which for obvious reasons will never occur again. The story of the American bison is familiar. The great baleen whale is verging on extinction; the quagga has probably gone; the great white rhinoceros—the largest terrestrial mammal after the elephant—is almost gone; the giraffe is fading away, and so on through a dismal list. Mr. Martin's Castorologia: the book of the beaver, might be described as the funeral oration on a dying race. The tale of disappearing birds is heart-rending, and here we may quote a paragraph from one of our most picturesque naturalists, Mr. C. T. Hudson. After describing the American ostrich or Rhea—notable for its fleetness, "great staying powers, and beautiful strategy when hunted," and for its strange habit of "running with one wing raised vertically, like a

(beside which national debts are trifling) and mortgaging in the direst sense future generations, so surely is it doomed to disappear, and justly—"in the gathering blackness of the frown of God." On the other hand, we may strengthen our hands in the assurance that no race is likely to be lost in

great sail—a veritable ship of the wilderness," Mr. Hudson writes as follows:

"Rhea-hunting, the 'wild mirth of the desert,' which the native horseman has known for the last three centuries, is now passing away, for the Rhea's fleetness can no longer avail him. He may scorn the horse and his rider, what time he lifts himself up, but the cowardly murderous methods of science, and a systematic war of extermination, have left him no chance. And with the Rhea go the flamingo, antique and splendid, and the swans in their bridal plumage and the rufous tinamou—sweet and mournful melodist of the eventide; and the noble crested screamer, that clarion-voiced watch-bird of the night in the wilderness. These, and the other large avians, together with the finest of the mammalians, will shortly be lost to the pampas as utterly as the great bustard is to England, and as the wild turkey and bison and many other species will shortly be lost to North America. Like immortal flowers they have drifted down to us on the ocean of time, and their strangeness and beauty bring to our imaginations a dream and a picture of that unknown world immeasurably far removed."

What can be done to stop this? We should abstain from all products which mean the extinction of fine types; we should try to appreciate what is being lost in their æsthetic, scientific, and economic aspects; we should raise a prejudice against ruthless sport; and at the worst we should try to secure the conservation of tracts of country in which the waning life may be preserved.

which it is the loyal endeavor of each pair to leave after them not their worse, but their bettered selves.

Fourthly, the most important impression we get is that of the gradual ascent of life. As the ages passed, higher and higher[1] animals are seen. Fishes were on the scene before Amphibians, Reptiles before Birds.

All theory apart, in the course of the ages life has been slowly creeping upward, finding finer and finer expression, and not along one line only, but along many lines. It is not among backboned animals only that we find the creature reaching toward a greater fulness of life, a greater richness of experience, and an increased freedom from the grip of the environment. Notably there is along many lines an increasing complexity of nervous system, and a correlated liberation of the Psyche.

[1] This is not an anthropomorphic impression. We do not mean by "higher" merely liker man; we use the twofold standard of differentiation and integration. Differentiation is the structural side of division of labor, it means increased complexity and specialization of parts. Integration means the consolidation, harmonizing, and regulation of the body into a more and more perfect unity. Thus just as a modern locomotive is a finer product than Stephenson's "Puffing Billy," in being much more differentiated and integrated, so the bird is a much higher animal than the earthworm. That we do not mean liker man is obvious when we say that the grass is a much higher plant than the seaweed. It is much more differentiated and integrated, but it is not any nearer man.

Let me quote a paragraph—freely translated from Gaudry:

"The organic world as a whole has made progress. Suppose a voyager on the oceans of ages; in the Cambrian times his barque meets trilobites, but no fishes; he nears the shore, and there is the silence of death. After long voyaging he finds himself at the end of the Primary era; fishes have replaced trilobites, and on land there is no longer silence. Here is the tramp and cry of reptiles who prophesy the advent of warm-blooded vertebrates. The traveller sails from age to age, and reaches the middle of the Secondary era. Charmingly beautiful ammonites play around his vessel, legions of belemnites mingle with them; ichthyosaurs, plesiosaurs, and teleosaurs follow his track. He goes ashore, and the giant deinosaurs resting on their tails open their huge arms; pterodactyls and other dragons swoop aloft; the first bird tries its wings, and some small mammals show face timidly. Nature, marvellous in the Primary ages, has become yet more marvellous; it has made progress. If our traveller be not fatigued with his long wanderings, he will find in the Tertiary ages the first monkeys and horses, and a thousand other mammals. Later on he will find himself—the man—artist and poet—minister and interpreter of nature—the man who thinks and prays. Truly, the history of the world as a whole is the history of a progressive evolution. Where will this solution lead us?"

Looking back again at the more than plausibly worked-out history of backboned animals, we see that the evolution is marked by a progressive differentiation of the nervous system, and that the use made of this is to adapt the organism more per-

fectly to its environment, and in the higher forms to adapt the environment to the organism. Surely one legitimate deduction—so obvious that many miss it—is just this, that the primary use of our highly evolved nervous system is not to enable us to construct philosophies, but to empower us to adapt ourselves more perfectly to the inexorables, "moulding the exile to his fate," and to empower us to reach a greater mastery of Nature, to enter into our Kingdom, and to win a firmer control of life. We are all too apt to take an unnecessarily academic view of our destiny.

What do we mean by "entering into our Kingdom"? We mean that, having gone so far, we must go further in our mastery of natural powers, in our utilization of natural resources, in our revolt against natural selection. Eutopias we want, a replacing of slums by garden cities, a sweeping away of the disfigurements with which we have half-spoiled beautiful places, landscape-gardening on a large scale, instead of the accumulation of ash-heaps. Eutechnics we want, healthful, pleasurable function well distributed, and an ending to occupations which mean miserable lives and untimely deaths. Eugenics we want, an improvement of the human breed, an active pride of race, an enlightened conscience as to marrying and having children, and a more evolutionary education. How much more we want and must

have! We have only begun to enter upon our Kingdom.[1]

Factors in Evolution.—When we pass from the modal formula of organic evolution to consider how the process works, we pass from clearness to perplexing uncertainty. Huxley's saying, "If the Darwinian hypothesis (of Natural Selection) were swept away, evolution would still stand where it was," has puzzled some, but it obviously means that while all research strengthens our confidence in the general idea of organic evolution, we are very uncertain as to the actual mechanism. The fact of evolution forces itself upon us; the factors elude us. There can be no dogmatism. The consistent evolutionist knows that he and his interpretation, like the world which he studies, are within the sweep of the evolution process, have been evolved, and are still evolving. He never claims finality of interpretation, for that would be self-contradiction.

Variations: The Raw Materials of Progress.—The first great question concerns what may be called the raw materials of progress—the origin and nature of those organic changes or variations on which the possibility of evolution depends. Darwin started from the broad fact that variability exists, illustrating it chiefly from domesticated animals and cultivated plants; he postulated an

[1] See Sir E. Ray Lankester's "Kingdom of Man," 1907.

abundant crop of organic changes, toward tares and toward wheat, and he showed how a process of thinning and singling, sifting and winnowing, would operate upon the ever-growing, ever-changing crop, so that the result was progress.

But all science begins with measurement, and the great step in advance that has been made of recent years is in the dry and tedious, but peremptorily necessary task of accurately recording the variations that do actually occur. Life is so abundant and so Protean that biologists have tended to draw upon the variability account as if there was no limit to it, scarce waiting to see whether their cheques were honored. Without being biologists, simply as clear thinkers, we must feel the unsatisfactoriness of merely postulating variability to meet the demands of particular problems. In ordinary evolutionist discourse, as Mr. Bateson justly points out, there has been continual use of the argument, "If such and such a variation then took place and was favorable," *then* . . . , a mode of talk which we would ridicule in Paley or Butler, but which we in our inconsistency still tolerate in ourselves. It is obviously our business to be able to say, "such and such variations *do* occur in Nature, therefore. . . ." But we are now changing all this. The very title—"Biometrika"—of a new journal is a sign of the times. *In hoc signo laboramus.* The recording and sta-

tistical registration of organic changes that actually occur is rapidly helping us out of the slough of vagueness, in which, to the physicist's contempt, biology has so long floundered. It is too soon to sum up the results of recent studies on variation, but some facts are clear.

(1) Variability is even greater than Darwin supposed, and is not less among creatures living in a state of nature than among those domesticated or cultivated forms on which the great master concentrated his attention. Whenever we settle down to measure, to identify, to describe, we find that specific diagnoses are average statements, that specific characters require a curve of frequency for their expression, that the living creature is usually a Proteus. It is true that there are long-lived, non-plastic, conservative types, built, as it were, not for a day, but for all time, like Lingula, and perhaps a score of other well-known organisms, where no visible variability (of hard parts, at least) can be proved even in a million years. But to judge from these as to the march of evolution is like estimating the rush of a river from the eddies of a sheltered pool.

(2) It has become possible to distinguish between minute *fluctuations*, which seem to be of general occurrence, in which the offspring has a little more or a little less of a given character than its parents had, and *discontinuous variations* or

mutations, in which something new emerges suddenly without gradual stages and with no small degree of perfectness. Using Galton's simile we can picture a polyhedron oscillating or rocking on one of its faces, this would be fluctuation; we can picture it rolling over to a position of equilibrium on another face, this would be mutation.

Though there is some truth in Lamarck's saying that "Nature is never brusque," and though we may justifiably disbelieve entirely in grotesque "Jack-in-the-Box" phenomena, such as Bastian's "Heterogenesis" (*e. g.*, the origin of a large infusorian by the transformation of a Rotifer's egg), which would make Nature magical and irrational, we now know, through the work of Mr. Bateson and others, that discontinuous variations are not rarities. In particular we know through the beautiful work of De Vries on "Evening Primroses and Other Plants," that organisms may give rise to offspring which are distinctively new, and that these are mutations come to stay. Such words as "freaks" and "sports" are not very happy, but they suggest the idea of what Mr. Galton calls "transilient" variations—the fact that organic structure may pass with seeming abruptness from one position of organic equilibrium to another. We have, in short, to deal with a Proteus who *leaps* as well as creeps.

De Vries' Evening Primroses.—Let us recall, for a moment, the case of the Evening Primrose (*Oenothera lamarckiana*), which Professor Hugo De Vries found as an escape in a potato-field at Hilversum in Holland. Its chief interest was its changefulness; it was, so to speak, frolicking in its freedom; it was in a variable mood. Almost all its organs were varying—as if swayed by a restless tide of life. It showed minute fluctuations from generation to generation; it showed extraordinary freaks such as fasciation and pitcher-forming; it showed hesitancy as to how long it meant to live, for while the majority were biennial, many were annual, and a few were triennial; best of all, it showed what could hardly be otherwise described than as new species in the making. From this stock, De Vries obtained in a short time half a dozen or more distinct varieties or elementary species, breeding true generation after generation. In short, he was fortunate enough to have found a plant in process of rapid evolution. It is rash to generalize as yet, but other cases of mutation are now being studied, and it may be that in many instances "new varieties are produced from existing forms by sudden leaps." If there are many such cases, the aspect of the evolution theory will have to be changed; we shall attach less importance to the accumulation of minute fluctuations, and we shall not have to lay such

a heavy burden on the shoulders of natural selection.

The Organism is a Unity.—(3) It is also becoming more and more evident that the living creature varies, in many cases, as a unity. If there is more of one character, there may be less of another; one change brings another in its train. As Darwin pointed out, there is a "correlation of variation." We see one part varying and we can plausibly say that its changes in a given direction are useful and life-preserving, but meanwhile there may be in the train of this observable variation another which is destined to be of far greater import. Another aspect of the same idea, illustrated for instance by the authors of "The Evolution of Sex,"[1] is that changes apparently confined to minute and superficial parts may be, as it were, the correlated outcrop of deeper physiological variations of the whole system or of a large part of the system. As Professor Ray Lankester says,[2] "We should, perhaps, more generally conceive of variation as not so much the accomplishment and presentation of one little mark or difference in weight, length, or color, as the expression of a *tendency to vary* in a given tissue or organ in a particular way. Thus we are prepared

[1] P. Geddes and J. Arthur Thomson, "The Evolution of Sex," "Contemporary Science Series," Revised Edition, 1901.

[2] "The Kingdom of Man," 1907, p. 132.

for the rapid extension and dominance of the variation if once it is favored by selective breeeding."

Modifications.—Besides variations which spring from within—emerging from the penetralia of the germ-cells, where lies the fountain of all lasting organic change—there are *modifications* superinduced from without. They may be defined as changes wrought in the body of an individual during its lifetime, as the direct result of changes in function and environment, which so transcend the limits of organic elasticity that they persist after the inducing conditions have ceased to operate. The peculiarities in our finger prints are variations, but the callosities on our hands are modifications. The inborn peculiarity of our facial physiognomy is a variation, but sunburning which lasts for years is a modification. These modifications or acquired characters are often of great personal importance and they may also serve as temporary shields or screens for incipient inborn variations in the same direction, but they have not been proved to be of direct importance in the evolution of races, since there is no convincing evidence that they can be transmitted as such or in any representative degreee. In short, organic progress is primarily due to changes in heritable *Nature*, not to changes in *Nurture*.[1]

[1] See J. Arthur Thomson, "Heredity," Murray, London, 1908.

Causes of Variations.—As to the causes of variations and mutations we know very little. We must still repeat Darwin's words, "Our ignorance of the laws of variation is profound. Not in one case out of a hundred can we pretend to assign any reason why this or that part has varied." It is probable that variability is, like growth, a primary quality of living things, and that "breeding true" has arisen secondarily as a restriction. The relation of genetic continuity between successive generations is an economical arrangement which secures relative constancy amid continual flux. In spite of this, however, the Proteus continually asserts itself. There may be, for all we know, a process of growing and varying inherent in the germ-plasm, requiring only an occasional environmental stimulus to keep it agoing. We must remember that the germ-plasm, though marvellously stable in its general architecture, has the instability involved in great complexity. Surrounding it there is the very complex, very variable, nutritive environment of the body. In the processes of maturation there is an extraordinarily elaborate shuffling of the cards which we call chromosomes. In fertilization, at the beginning of almost every new life, we see the making of a living mosaic of parental and ancestral contributions, and there is abundant opportunity for new permutations and combinations.

Directive Factors in Evolution.—We must pass now to the directive factors which operate upon the raw material afforded by variability. The only directive factors we know of are included in the terms Selection and Isolation. These are the twin directive genii.

Selection.—The theory of Natural Selection, which Darwin and Wallace first expounded, is very familiar, and admits of brief statement. Variability is a fact of life. The members of a family or of a species are not born alike; some have qualities which give them an advantage, both as to "hunger" and as to "love"; others are relatively handicapped. But a struggle for existence is also a fact, being necessitated especially by the abundance of life and by the changefulness of the environment. Two parents usually produce many more than two children, and the population thus tends to outrun the means of subsistence; moreover, living creatures are at the best only relatively well adapted to the conditions of their life, which are changeful. As the result of this struggle for existence, there is discriminate elimination, the relatively less fit being eliminated before they reproduce. "Of fifty seeds, she often brings but one to bear." The relatively fitter tend to survive and to reproduce, handing on their advantages to their progeny. If advantageous variations are transmitted, if variations in the same

direction crop up generation after generation, if there is gradual augmentation of the amount of the profitable peculiarity (through the pairing of similar variants or otherwise), and if the discriminate selection continues consistently, then the process will necessarily work toward the establishment of new adaptations.

Given a sufficient crop of variations and sufficient time, what may a process of selection not effect?

Conditions of Progress through Selection.—There are two conditions, however; first, that some of the variations continually occurring are in the direction of fitness, and secondly, that the process of elimination, for elimination it comes to, is a discriminate process. Neither of these conditions is to be lightly passed over. The occurrence of variations in a profitable direction is often a great puzzle, which has led some to take refuge in verbalisms, "inherent tendencies to perfection," and the like. Especially when the new departure is not merely quantitative, but qualitatively novel, and exhibited suddenly, is the puzzle great. We have a Mutation Theory, but no theory of mutations. Natural Selection, as some one says, explains the survival of the fittest, but not the arrival of the fittest. As usual, it is a question of the beginnings which gives us pause. And as to the second point, we must be clear that indiscrimi-

nate elimination does not count for much in nature's methods. We see the men in the fields thinning or singling turnips. With rapid strokes of the hoe they kill nine and leave a tenth, giving it elbow room, and liberating it from too intense competition. But they do not pause to select out the most vigorous young turnip plant; this would be discriminate selection, which we are familiar with in the more intensive cultivation of the garden. On the whole, the process of thinning turnips is indiscriminate elimination, though, of course, one knows that the survivors are left at regular distances, and so forth. The point is that while this thinning is profitable for the surviving individuals, it does not directly help the race, it does not make for the evolution of superior turnips. So it is in Nature's thinning and singling; it is only *consistent discriminate elimination* that counts for much.

One hundred and thirty-six English sparrows in America were worsted by a severe storm and were brought benumbed into a laboratory. Seventy-two revived, sixty-four perished. Professor Bumpus made a careful comparison of the eliminated and the survivors with the result of showing that the birds which perished because of the storm were deficient as regards certain qualities in which those that survived were stronger. In other words, this storm, at least, was an agent in discriminate elimination.

Struggle for Existence.—In thinking of the process of Natural Selection, it is of real importance to recognize, with Darwin, that the phrase "struggle for existence" is used "in a wide and metaphorical sense," including much more than an internecine scramble for the necessaries of life—including indeed all endeavours for preservation and welfare, not only of the individual, but of the offspring as well. The struggle expresses itself not merely in an elbowing and jostling around the platter, but at every point where the effectiveness of response which the creature makes to the stimuli playing upon it, is of critical moment. It is much more than a long-drawn-out series of family quarrels ending in more room and food for a few surviving members; it may often be more justly described as an endeavour after well-being. And what may have been primarily self-regarding impulses become replaced by others which are distinctively species-maintaining, the self failing to find realization apart from its family and its kindred.

We may gain some clearness when we notice that struggle is manifold.

(1) It may be between near kin as when a tadpole eats its brother tadpole, or when the embryos in the dog-whelk's capsule on the shore play the same game, and illustrate cannibalism in the cradle, or when locust devours locust, and rat kills

rat. Under this category we have to include the struggles of rival males, as among stags, and the strange struggles of the sexes, as in spiders.

(2) It may be between organisms not nearly related, as between carnivores and herbivores, between plants and snails.

(3) It may be between organisms and the inanimate environment, as between birds and the winter—a form of struggle entirely non-competitive.

Or, again, we may distinguish different forms of the struggle according to what is achieved by it —survival from immediate death, a longer life, a more comfortable life, a larger family, a more successful family, and so on.

In regard to the process of elimination, we must carefully notice that it does not necessarily mean that those eliminated come at once to a violent end, as when locust devours locust, or the cold decimates the birds in a single night; it often means simply that the less fit die before the average time, or are less successful than their neighbors in rearing progeny. But whether the eliminative process be quick or slow, gentle or severe, competitive or environmental the result is the same, that the relatively more fit tend to survive. We need not waste time in combating the absurd misunderstanding that fittest means best or highest according to any evolutionary standard; it only means fittest relatively to given conditions. The tape-

worm is not exactly what one would call a noble animal, but after it gets settled down in its host it is remarkably well adapted to its own peculiar conditions of material well-being. The golden eagle is a much finer creature than, say, the microbe of grouse disease; but, as things are, the chances of the golden eagle's survival in Britain are much less than those of the grouse-microbe.

There are some naturalists who will not accept the interpretation of the struggle for existence which has been outlined above, which seems on the whole consistent with Darwin's. Thus Professor Ray Lankester writes, it seems to us unwarrantably, "In Nature's struggle for existence, death, immediate obliteration, is the fate of the vanquished." "The struggle between species is by no means universal, but in fact very rare. The preying of one species on another is a moderated affair of balance and adjustment which may be described rather as an accommodation than a struggle." "The 'struggle for existence,' to which Darwin assigned importance, is not a struggle between species, but one between closely similar members of the same species." ("The Kingdom of Man," 1907.) As a matter of fact, Darwin assigned importance to many different forms of the struggle for existence. Even when we take his paragraph headed, "Struggle for life most severe between individuals and variations of the

same species; often severe between species of the same genus," we find only five illustrations, and these are not altogether convincing.

Isolation.—Besides selection we can discern another directive factor—what we call Isolation. One of the early competent critics of Darwin's theory of Natural Selection, Professor Fleming Jenkins, emphasized the difficulty that variations of small amount and sparse occurrence would tend to be swamped out by intercrossing. In artificial selection, the breeder takes measures to prevent this by removing unsuitable forms and by deliberately pairing similar and suitable mates; but what in Nature corresponds to the breeder? There are several ways of meeting this criticism, but the one that concerns us at present is the theory of isolation, worked out by the late Dr. Romanes, by Mr. Gulick, and others. Attention is directed to the great variety of ways in which, in the course of nature, the range of intercrossing is restricted—for instance, by geographical barriers, by differences of habit, by likes and dislikes, which result in assortive mating, by reproductive variations which cause mutual sterility between two sections of a species living on a common area, and so on. According to Romanes, "without isolation, or the prevention of free intercrossing, organic evolution is in no case possible." It has to be confessed, however, that the body of facts

in illustration of this thesis is still unsatisfactorily small, though it is interesting to note that each valley in the Sandwich Islands seems to have its own particular species of snail, just as almost every mammal has its own peculiar parasites.

An interesting corollary to the theory of isolation has been pointed out by Professor Cossar Ewart. Breeding within a narrow range often occurs in nature as the result of geographical or other barriers. In artificial conditions, this inbreeding often results in the development of what is called prepotency. This means that certain forms have an unusual power of transmitting their peculiarities, even when mated with dissimilar forms. In other words, certain variations have a strong power of hereditary persistence. Therefore, wherever through inbreeding (which implies isolation) prepotency has developed, there is no difficulty in understanding that even a small idiosyncrasy may come to stay. Reibmayr has developed the interesting thesis that in the evolution of a successful human stock there must be an alternation of long periods of inbreeding, in which characters are fixed and prepotency developed, and periods of outbreeding, in which fresh blood is introduced and the possibility of new departures secured.

General Retrospect.—Nature, Goethe said, is a book whose every page is full of import, and that is particularly true of the pages of the history of the

animate world. Here the general trend of things has been progressive. How important if we can spell out the mechanism of progress! In this connection we venture to submit some general considerations.

A Common Error as to Fortuitousness.—Many have recoiled from a theory of evolution which seemed to rely so much on happy chances and on the occasionally apt ending of a chapter of accidents. What have we to say to this?

It is in part a misunderstanding of words. When an evolutionist speaks of "fortuitous variations," he means that he is ignorant of their antecedent conditions. Fluctuating variations can be arranged so as to form a curve—the curve of the frequency of error—the curve which we get when we plot out measured results depending on a number of variable conditions. But the mere fact that we can make the curve shows a certain orderliness of distribution. Chance is a most orderly phenomenon. Furthermore, there is often marked definiteness in continuous variation, it accumulates generation after generation, one organ increases, another dwindles. Furthermore, it is by no means certain that any big step has been made by the accumulation of minute fluctuations; it is probable that discontinuous variations or mutations have counted for much, and they are no more accidental than sudden growth is. Furthermore, while there have been catastrophes in the course of

nature, the only kind of elimination that counts in evolution is discriminate elimination, and what is discriminable cannot be fortuitous.

There seems to be nothing but misunderstanding in the allegation that the evolutionist interpretation relies on fortuitousness. If a cone falls from the fir tree under which we are sitting and kills a spider creeping on the ground, we say that it is quite fortuitous that cone and spider happen to come together at the same time in the same place. But progress in Nature does not depend on this sort of phenomenon. The elimination that counts is discriminate elimination.

But are not *the variations that count* fortuitous? It is difficult to see much meaning in the term except that we are very ignorant of the antecedent conditions. Whether we believe that discontinuous mutations are of most moment, or that the fluctuations Darwin relied on are more important, whether we believe that variation is due to the stimulus of the variable body on the complex germplasm or to a germinal struggle of hereditary items, there is no good reason for calling them fortuitous. We must get away from the wooden way of thinking of variations as if they were so many coins which the organism took out of its pockets and staked in the game of life. Variations are always expressions of the creature's individuality, of its creative genius; they correspond to the poet's

fancies and the philosopher's hypotheses; they represent *organic imagination.*

Preciousness of Individuality.—An evolutionary lesson which he who runs may read concerns the preciousness of individuality. Variations supply the raw material of progress, and variations spell individuality. This is one of the biological commonplaces which in human affairs we persistently ignore. In the educational mill—whether of school or of college—and in our inexorable social criticism, how systematically we pick off the buds of individuality—idiosyncrasies and crankiness we say—spoiling how many flowers. It is said that we do this to prevent failures and criminals, but are we very successful in this prevention? How many of both do we make by repressing individuality?

Importance of Struggle and Endeavour.—If there is one thing that the story of organic evolution teaches us more than another, it is the necessity of struggle or of endeavour. Everywhere she pronounces judgment on slackness, on the unlit lamp and the ungirt loin. Meredith writes of Nature's sifting:

> "Behold the life of ease, it drifts,
> The sharpened life commands its course;
> She winnows, winnows roughly, sifts
> To dip her chosen in her source.
> Contention is the vital force
> Whence pluck they brain, her prize of gifts."

More than Competitive Struggle.— At the same time, we libel nature's method if we picture it as comparable to that of a gladiatorial show with its uncompromising cry *Væ victis;* if we say that her only word is ruthless self-assertion, every one for himself and extinction take the hindmost; if we see only a thrusting aside and treading down of competitors.

Tennyson, who held such a clear mirror to Nature, writes:

> "For Nature is one with rapine, a harm no preacher can heal,
> The may-fly is torn by the swallow, the sparrow spear'd by the strike,
> And the whole little wood where I sit is a world of plunder and prey."

But this is only one side of the picture.

It appears to us that the facts of mutual aid, of social life, of kin-sympathy and of parental care suffice to show that Huxley was in error in saying that "the cosmic process has no sort of relation to moral ends." This is so important that we must consider the matter more fully.

Ethical Aspect of Organic Evolution.—For untold ages the drama of organic evolution has been in progress, cast succeeding cast without any one having a real grasp of the plot. In comparatively recent times man, though busy on the stage, has become a calm spectator. Is it not significant of

his critical spirit that he has come to doubt whether the great drama is a moral spectacle?

Darwin painted a picture of nature which has impressed itself now on two generations of students. Every competent judge recognizes its strength and insight, but it is anti-Darwinian to call it finished or perfect. The most prominent features which it brought out were—that flux of form which we call variation, the tendency of the river of life to overflow its banks, the ceaseless struggle for existence, the discriminate elimination which results, and the subtle interrelations and adaptations of the web of life. It is with the struggle for existence that we have now especially to deal.

Darwin pointed out that the phrase "struggle for existence" was to be taken in a wide and metaphorical sense, and he has a number of very interesting saving clauses. But the general perspective of his picture is clear, and leaves us with the impression of a sombre, more or less sanguinary, ceaseless struggle. We remember that the work of Malthus influenced Darwin (as it also influenced Wallace and Spencer); we may go further and recognize some truth in Geddes' thesis that science is a social phenomenon, and that the Darwinian conception was in part an unconscious projection on nature of the competitive conditions and competitive creed of the early industrial age. A reproduction of the picture has never the subtlety

of the original, and the reproductions of the Darwinian picture are often rather hard and ugly prints. Nature is represented as a continuous Waterloo, as an endless gladiatorial show, as a dismal cockpit. And popularizers apart, leaders of thought like Huxley, have strengthened this impression, which is, to say the least, one-sided.

Attempt at a Correction of the Ultra-Darwinian Picture.—Let us make a curve of the ascent of Vertebrates from water to dry land, and mark the position of the leading types according to the degree of their brain-development (which is generally a reliable index of structural progress). As the curve ascends, we find that the plummet of marital affection, the intensity of parental care, the expression of the gentler emotions, are all on the increase. The natural conditions in which each is said to be for himself, are evidently not antagonistic to the evolution of other-regarding behaviour.

The non-gregarious mammals are outnumbered by those that are social; the most secure, successful, and highly gifted birds are probably the rooks, the cranes, and the parrots—also among the most gregarious; the monkeys—most of which are a feeble folk—are strong in their sociality. It is not then to self-assertiveness alone that Nature gives her sanction of survival.

When we take a survey of the course of organic nature we see hunger—self-assertion—competi-

tion—a nutritive struggle of variable intensity. But organisms are also reproductive, they have species-regarding activities, altruistic impulses. The careful brooding mother-bird is *de facto* altruistic. Hence, in part, a reproductive struggle, in which love may be stronger than hunger—a reproductive factor in evolution which is not wholly concerned with self-gratification, but with self-sacrifice as well.

The important points are (1) that many of the big lifts in animal evolution, such as the origin of multicellular organisms or the origin of the mammalian type, imply the success of variations which cannot be regarded as of immediate individual advantage; (2) in the process of selection the premium on teeth and claws, or beaks and talons, is no greater than that on "the milk of animal kindness" and the warmth of the maternal heart; (3) the struggle for existence is often a quiet endeavour after well being. There is much gregariousness, there are many peaceful solutions of difficulty, there is frequent combination for defence and attack, there is a strong feeling of kinship, there is frequent coöperation and mutual aid. The world, Diderot says, is the abode of the strong; but it is also the home of the loving.[1]

[1] We do not quote Nietzsche as an authority, but it is interesting that one who preached the gospel of the strong, and regarded the real thing in Nature as the

Just as in the individual body we recognize the coöperation of organs as well as the struggle of parts, so in the great world of organisms we must recognize not only competition but coöperation, not only struggle but mutual aid, if we would draw any sane conclusion as to the ethical import of the great drama. As against Huxley's conclusion that the course of organic evolution—through "a materialized logical process"—has no ethical suggestion except that man must try to go on the opposite tack, it is interesting to place Geddes' conclusion that "Nature is a materialized ethical process," meaning by this mainly that some of the greatest steps in organic progress are interpretable as subordinations of the nutritive and self-regarding to the reproductive and species-regarding activities.

We must, of course, be careful not to pass from one anthropomorphism to another. We must be careful not to read the man into the beast, still less into the plant. Many animals exhibit self-sacrifice in the sense that they exert themselves often to their own detriment on behalf of their young, but this is not done out of a sense of duty any more

"Will to Rule," should have—most impudently, of course—described Darwin as "one of those mediocre Englishmen who have coarsened the mind of Europe," "an intellectual plebeian, like all his nation," and should have called the struggle for existence "an incredibly one-sided doctrine," as a description of the normal aspect of life in nature.

than in the case of a human mother. In many cases, among insects, the mothers never see the young for which they labour. The mother mammal has no prevision of the welfare of the species, no control of her behaviour in reference to an ideal standard. Good she is, but not moral. None the less, there is objective self-sacrifice, and there is so much of it and of kindred phenomena that we must in accuracy correct the picture of Nature "all red in tooth and claw with ravine."

It is also evident that all the other-regarding activities *pay*, and are the subjects of selective direction. The selection-formula which applies to the swiftness of the fox and the correlate swiftness of the hare, applies also to the patient brooding of birds and the carefulness of the mammalian mother. Yet it seems absurd to deny that these mothers love their children, or to assert that physical motives saturate their behaviour. Is there not then some shifting of the theory's centre of gravity when we expressly allow that love pays? The whole law and gospel of Nature is not to be summed up as "Upstairs on your neighbour's shoulders, living or dead, each for himself in the scrimmage and elimination take the hindmost." On *a priori* grounds it seems unlikely that struggle is the only word Nature has to say to man, or that what we recognize as one of the great laws of moral development—self-realization in self-

sacrifice—should have no far-off counterpart in the rest of creation. We have hinted at *a posteriori* reasons for the belief that in this sense there are spiritual laws in the natural world, but what we have said must be followed up by reference to such contributions to the subject as Kropotkin's "Mutual Aid."

It may perhaps be objected that parasitism is a frequent phenomenon among animals, and has Nature's sanction of survival and success. The parasites are indeed legion; they attain conditions of "complete material well-being"; in spite of the enormous odds against them, involved in their usually intricate life-histories, full of hazardous vicissitudes, they hold their own. Fit for certain conditions, they survive, and survive uncommonly well. All this is true, but it is equally true that parasites are stamped with the stigmata of degeneracy.

The reason why we are so much concerned with getting away from an ultra-Darwinian picture of Nature is not merely because it seems to us inaccurate, but because the libellous conception projected from human society upon Nature has been brought back again to society as a guide and sanction of human conduct, even as an ethical and political ideal.

"The conception of the struggle for existence, it has been said, comes back to the explanation of human society with all the added force of its tri-

umph in the solution of the greatest question with which natural science has hitherto successfully dealt."

Let be, they say, let nature alone, let them fight it out. Through struggle all progress has come, contention is the world's vital force, "the survival of the fittest," don't you know, in the struggle for existence. Let be, let be. The law of nature is every one for himself; there is a Hobbesian war of each against all; all creatures are Ishmaelites; and are not the results fair to see?

Even if this were so, it is difficult to see why man, conscious of all, and in a sense above all, should fold his hands and say that Nature's method is good enough for him. As a matter of fact, Huxley's noteworthy thesis was that ethical progress for man depends upon his combating the cosmic process, pitting his microcosm against the macrocosm.

What we have been trying to show, however, is that Nature has more to say than "Every one for himself." There has been a selection of the other-regarding, of the self-sacrificing, of the gentle, of the loving.

If we wish to draw any ethical deduction from the course of organic evolution, we must have all the facts before us. We must not make idols of phrases, or rest content with partial pictures, or with projecting our social creed on Nature; we must go to Nature itself. When we do so, we

find indeed that there is often competition to the death, much pain and suffering, very intense struggle for food and foothold. We may echo Darwin's sad words that the world is "too full of misery." We may say with Huxley that suffering, "this baleful product of evolution, increases in quantity and in intensity with advancing grades of animal organization until it attains its highest level in man." But this is not all. We see the success of self-sacrifice, the rewards of love, the stability of societies, and no end of *joie de vivre*. We find that the phrase struggle for existence has indeed to be used in a wide and metaphorical sense, that it is descriptive of the course of nature in which the multiplication of organisms and the natural limitations put to their desires for food, foothold, comfort and mates, bring about a state of affairs in which a premium is put on advantageous variations of whatever kind, and in which an elimination more rapid than natural death, or a lessening of the normal number and success of the family, handicaps those which are relatively unfit.

It seems important that we should try to make up our minds whether Huxley's picture of the course of animate nature is adequate. Must we not recognize that progress depends on much more than a squabble around the platter; that the struggle for existence is far more than an internecine struggle at the margin of subsistence, that it in-

cludes all the multitudinous efforts for self and others between the poles of love and hunger; that self-sacrifice and love are factors in evolution as well as self-assertion and death; that existence for many an animal means the well-being of a socially-bound or kin-bound creature in a social environment; that egoism is not satisfied until it becomes altruistic?

Emotional Value of the Evolutionary Picture.—Finally, as to the æsthetic value of the evolutionary picture, let us recall Darwin's well-known words: "To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of an individual. When I view all beings, not as special creations, but as lineal descendants of some few beings who lived before the first bed of the Silurian was deposited, they seem to me to become ennobled."

"There is a grandeur in this view of life, with its several powers having been originally breathed by the Creator into a few forms or into one, and that while this planet has gone cycling on, according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been and are being evolved."

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MAN'S PLACE IN NATURE

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MAN'S PLACE IN NATURE

Man's Zoological Position and His Distinctive Peculiarities.—Science speaks with no uncertain voice regarding man's position among other living creatures. Zoologically regarded, Man belongs to a special family in that order of Mammals which we call Primates, which includes marmosets, American Monkeys, Old World Monkeys, and Anthropoid Apes. Of his structural resemblance to the Anthropoid Apes in particular there is not a shadow of doubt. It is long since Sir Richard Owen, who was conservative on the subject, admitted the "all-pervading similitude of structure." On the other hand, man is a very distinctive type. He alone, after his infancy is past, walks thoroughly erect. His head is weighted with a heavy brain, but it does not droop forward. With his upright attitude, his command of vocal mechanism is perhaps in part connected. He plants the soles of his feet flat on the ground and he has a better heel than the monkeys have. Comparing his head with that of the anthropoid apes, we notice the bigger forehead, the less protrusive face, the smaller cheekbones and eye-brow ridges, the absence of cranial

crests, the early disappearance of the junction between premaxilla and maxilla, the well-marked chin, the more uniform teeth forming an uninterrupted horseshoe-shaped series without prominent canines, and above all the massive brain which may be three times the weight of a gorilla's. There is no need to go into details, which have been authoritatively stated so often. The point is, that while man is distinctive from his heel to his chin, from his big toe to his forehead, there is, as far as structure is concerned, much less difference between man and gorilla than there is between gorilla and marmoset. Every one now admits that the distinctiveness of man from his nearest allies depends not on anatomical peculiarities, important as they are, but on his *powers*, especially on his powers of rational discourse, of building up general ideas, and of guiding his conduct by ideals. Some other creatures have words, but man alone has language—the power of expressing a judgment—which is *Logos*. Many other creatures have *intelligence*, which we can give a plausible account of in terms of perceptual inference, but man seems to stand alone in having *reason* or the power of conceptual inference. Many other creatures exhibit intelligent behaviour, which in a few cases may be controlled with reference to an objective end, as when the beavers dig a canal through an island in the river; but, so far as we

know, it is only in man that behaviour rises into ethical conduct. Many animals are delightfully good, but only man is moral.

Does Resemblance Mean Relationship?—But admitting that man, distinctive as he is, must be regarded as anatomically akin to the anthropoid apes, is it necessary to go further and admit that the homologies spell blood-relationship? Does the "all-pervading similitude" imply affiliation? Has there been an ascent of Man from a Simian stock? The practically unanimous scientific answer is "Yes." Before considering this answer, let us ask what other interpretations are in the field.

It has been suggested that Man is "The Great Exception," that while all other creatures have had a natural evolution, Man was specially created, that is to say, that he arose in a manner beyond the ken of science. If this answer thoroughly satisfies any one and is really useful to him, he should stick to it. It is not for science to say that it is impossible, for the only kind of impossibility which science has to protest against is a contradiction in terms. The strength of the position that Man is the great exception, with a peculiarly supernatural origin, lies positively in the fact that Man at his best is a very wonderful creature, and that even at his worst he is considerably different from an animal. It is also strengthened negatively by the fact that Man's origin is wrapped in ob-

scurity, and that the provisional hypothetical history, which zoologists and anthropologists have tried to construct, leaves much to be desired. On the other hand, the drawbacks to the theory are, that it dogmatically sets a limit to the unravelling power of science, that it insinuates a dualism into our scientific conception of history, and that it leaves us with the puzzle of the "all-pervading similitude" between Man and the anthropoids. In trying to save Man's dignity, it makes him a conundrum.

A somewhat subtler view, which finds favour with many, suggests that while Man as an animal organism was evolved, he received in addition to his natural inheritance a special supernatural endowment. As an organism he sprang from the very dust, but he also received a breath of divine life which nature could not give, which nature cannot take away. "There is surely," said Sir Thomas Browne, "a piece of divinity in us; something that was before the elements, and owes no homage unto the sun." According to Dr. Alfred Russel Wallace, the *doyen* of evolutionists, the Nestor of the Darwinian camp, the facts of Man's higher nature compel us to postulate a special "spiritual influx," comparable to that which intervened when living organisms first appeared and when consciousness began. If any one finds this view thoroughly satisfactory and really useful, he

should stick to it. From our point of view it seems premature and unnecessary. It abandons the scientific mode of procedure while the inquiry is still young, and the idea of spiritual influxes intervening now and again to help natural evolution over difficult stiles suggests that we have to do with two worlds and not with only one.

Ascent of Man.—But let us now turn to the scientific outlook. The arguments by which Darwin and others have sought to show that Man arose from an ancestral type common to him and to the higher apes, are logically the same as those used to substantiate the general doctrine of descent—that the present is the child of the past and the parent of the future. The "Descent of Man" is an expansion of a chapter in the "Origin of Species." The arguments may be briefly summarized:

(1) *Physiological.*—The bodily life of Man is very like that of his presumed allies. Men and monkeys are subject to similar diseases. Various human traits of gesture and expression are paralleled among the brutes. Friedenthal's curious physiological method of demonstrating blood-relationship by similarity in the blood reactions holds good.

(2) *Morphological.*—The structure of Man is very like that of the anthropoid apes. He is distinctive, but none of his anatomical distinctions,

except that of a large and heavy brain, are very momentous. There are about eighty vestigial structures in his muscular, skeletal, and other systems—a large museum of relics which he carries about with him, enigmatical except in the light of the past.

(3) *Historical.*—Certainties in regard to remains of primitive man are few, but some of the early skulls are nearer the Simian type than those normal to-day. Connecting links are missing, but fragments like those of *Pithecanthropus* are suggestive if not convincing. Sometimes, moreover, an abnormal type is born which seems to hark back in some of its features to a pre-human stage. And again we find in Man's individual development stages which may be interpreted as in a general way recapitulative of presumed ancestral history.

It goes almost without saying that we cannot regard these evidences of Man's pedigree as demonstrative. The evidences of evolution never are. We accept the doctrine of descent because it is our only scientific modal interpretation of the past, because it makes both past and present luminous and coherent, because all the facts point to it as a rational formula, and because we know of nothing that can be said to contradict it. If the doctrine of descent is true for other organisms, it is likely to be true for Man as well.

The Difficulty of the Problem of the Ascent of Man.— It must be admitted that the problem remains full of difficulties. We do not know how Man arose, or whence he came, or when he began, or where his first home was; in short we are in a deplorable state of ignorance on the whole subject. But consider for a little each of these points, taking them in reverse order.

The Garden of Eden is not yet known to geographers. We have only speculations as to the cradle of the human race. We may venture on negative statements, such as that it could not have been in the New World, but the fewer positive statements we make, the better.

As to the antiquity of the human race, it is certain that men lived in Europe at a time when mammoth and rhinoceros, hyæna and lion, frequented these parts. From the situations in which palæolithic implements have been found, it is inferred that these must have dropped from their makers' hands at least 150,000 years ago. And these implements were not the work of novices; in their well-finished form they compare favourably with some of the results of twentieth-century handicraft. But ever so much older than those palæoliths are the eoliths. They probably take us back to 300,000 years ago.

Another line of argument is this. It is certain that Man could not have arisen from any of the

existing anthropoid apes; it is a vulgar error to suppose that scientific interpreters ever made any such suggestion. It is likely, however, that Man arose from an ancestral stock common to the anthropoid apes and to him. It therefore seems justifiable to date the antiquity of the human race not later than the time when the anthropoid apes are known to have been established as a distinct family. This takes us back to Miocene ages, and that means many hundreds of thousands of years ago.

Is there not something extraordinarily impressive in this antiquity of our race, all the more impressive when we see that it is lost against the background of the immensely greater antiquity of the animal world, just as that is lost against the unthinkable antiquity of the earth? To those who are always in a hurry for results, as they put their shoulders to the wheel of the cumbrous wagon of our civilization, is there not some lesson simply in the time the past journey has taken? As Lowell said, we must "Learn by each discovery how to wait."

Man as a Mutation.—As to the actual origin of Man, we can only say that facts point to his natural evolution from an ancestral stock common to him and to the anthropoid apes. He probably arose by a *mutation*, that is to say, by a discontinuous variation of considerable magnitude. From the

researches of De Vries, Bateson, and others, we know that discontinuous (or as Galton called them "transilient") variations often occur. They represent sudden and brusque emergences of new constitutional patterns, and they often show great stability, *i. e.*, they tend to breed true. The birth of a genius gives us a hint of what a mutation may mean, but, unfortunately, geniuses do not usually beget geniuses. They do not breed true like De Vries' evening primroses! In suggesting that Man arose as a mutation, we do not mean, of course, that he sprang suddenly to the height of his dignity. It was perhaps more like what we see every day in the growth of a child. Probably his origin was like that of life itself, a great step was suddenly taken, but it was a long time before it began to tell. It may seem to some that there is not much to choose between a theory of Man's origin by a hypothetical mutation, which one would not understand even if one knew it had occurred, and a theory of Man's origin by special creation in which one does not believe. But the point is really, whether we do or do not regard Man as a natural and predetermined product of the antecedent order of nature.

Possible Factors in the Evolution of Man.—In regard to the conditions of Man's emergence as an anthropoid genius, we can only speculate. From what we know of men and monkeys, it seems likely

that, in the struggle of primitive man, wits were of more avail than strength. His bodily framework admitted of little more perfecting, and evolution "ever climbing after some ideal good" began, metaphorically speaking, to experiment with the brain. Sir E. Ray Lankester has called attention to the interesting fact that in the early Miocene times there was great increase in brain-growth in several animal types, perhaps for the same reason, that anatomical differentiation of the rest of the system could not profitably go much further. One of the first types to shoot ahead in brain-development was the elephant, which was already sagacious in Eocene times.

Now the possession of a big brain seems to mean great "educability," *i.e.*, power of storing and profiting by experience.[1] And man's enormous brain, which does not seem to have increased greatly in bulk since Palæolithic times, marked a new departure. It removed him head and shoulders above the rest of creation, enabling him to pit himself against Nature in a degree impossible to less endowed organisms. It raised him, to his

[1] "The power of building up appropriate cerebral mechanism in response to individual experience, or what may be called 'educability,' is the quality which characterizes the larger cerebrum, and is that which has led to its selection, survival, and further increase in volume." E. Ray Lankester, "The Kingdom of Man" (London, 1907).

own risk, from under the inexorable sway of Natural Selection.

When the habits of walking erect, of using sticks and stones, of building shelters, of living in families, began—and they have begun among monkeys—it is likely that wits would grow apace. The prolonged gestation would perhaps help the development of the brain and the prolonged infancy, characteristic of human offspring, would help the growth of gentleness. But even more important is the fact that among monkeys there are distinct societies. Families combine for protection, and the combination favours the development of emotional and intellectual strength. Nothing seems more certain, especially in the light of recent investigations, than that our mind is a social product. "Man did not make society; society made Man."

It behooves us to be extremely careful in speaking of the factors in early human evolution. We know so little. "In the case of mankind," Huxley wrote, "the self-assertion, the unscrupulous seizing upon all that can be grasped, the tenacious holding of all that can be kept, which constitute the essence of the struggle for existence, have answered. For his successful progress, as far as the savage state, man has been largely indebted to those qualities which he shares with the ape and the tiger; his exceptional physical organization,

his cunning, his sociability, his curiosity, and his imitativeness, his ruthless and ferocious destructiveness when his anger is roused by opposition." There is doubtless some truth in this, but it underappreciates what is also a plain fact of life that the success of the Mammalian type depends in great part on maternal care, that as Henry Drummond said, the "struggle for the life of others" is as important as the struggle for personal subsistence.

Repugnance to the Scientific Interpretation.—Many who are not unwilling to admit that there is a certain grandeur in the doctrine of descent as applied to plants and animals, express a strong repugnance to the whole idea of the Descent of Man. It may be useful to inquire into this repugnance, which is expressed by many clear-headed and noble-minded men and women. To some extent, it is due to misunderstanding. People run off with the mistaken idea that evolutionists try to prove that the chimpanzee is their second cousin or something of that sort; or they fancy that Man, according to biology, is no more than a freak, a strangely fortunate ending of a chapter of accidents. Or the reasons for the repugnance may have an æsthetic basis, since some people dislike anything in the nature of embryos, preferring to picture their ancestors always with gray hairs. They will not look on the rock whence they were hewn or into the pit whence they were digged.

This is a question of taste, and cannot be argued about. To most naturalists development is the most beautiful thing in the world, and the Hebrew psalmist was not averse to reminding himself how his members were fashioned when as yet there was none of them. More serious, however, is the idea that if Darwin's Descent of Man be true, then Man loses dignity, sanctity, and ethical value. In the first place, perhaps, it should be noted that the scientific interpretation discloses man as a predetermined masterpiece of nature, as a creature whose making meant ages of patience, whose birth came about after long travail. Is there loss of dignity and sanctity in this? And again, the more Man is seen as of a piece with nature, as her finest flower, the more meaning does nature come to have for him. She becomes indeed his Alma Mater.

A simple consideration, which is always useful, is that the value of any product is independent of its far-off origin. Our appreciation of things is usually based on what they are, and on what they seem likely to become; it is not affected by their remote pedigree. A bird is not less a bird because the avian stock arose from among the reptiles. It is true, of course, that breeding counts, but that is quite another matter; immediate ancestry is always important because the individual inheritance is a living mosaic of parental

and ancestral contributions. But when a great step in evolution has been taken—such as the origin of Vertebrates, or of any of the great classes of Vertebrates—Amphibians, Reptiles, Birds, or Mammals—our estimate of the advance made is not affected by our knowledge of the origin. To depreciate man because he had non-human ancestors is like judging a statue by the quarry. Is it a poor genealogy that the naturalists give man? But man may always say "*Je suis un ancêtre.*"

Perhaps the deepest repugnance is due to the misunderstanding to which we have already alluded, that according to science Man was a happy accident. But whatever careless writers may have said, this is not the scientific view. Take a sentence rather from one of the foremost exponents—Professor E. Ray Lankester: "Man is held to be a part of Nature, a product of the definite and orderly evolution which is universal; a being resulting from and driven by the one great nexus of mechanism which we call Nature." This may not be the whole truth about Man, but here at any rate there is no suggestion of fortuity. Again he writes, "Man forms a new departure in the gradual unfolding of Nature's predestined scheme." Mr. Balfour writes in the "Foundations of Belief" (p. 75): "An irrational universe which accidentally turns out a few reasoning animals at one corner of it, as a rich man may experiment at one

end of his park with some curious "sport" accidentally produced among his flocks and herds, is a Universe which we might well despise, if we did not ourselves share its degradation." This is hard hitting; but the rational Universe which admits of scientific formulation, does not turn out its masterpieces accidentally.

It is not necessary to enter into a discussion of Naturalism[1] which is a particular scientific philosophy with a name that one cannot but grudge to it. But when Mr. Balfour says that Man, according to Naturalism, is "no more than a phenomenon among phenomena, a natural object among other natural objects, his very existence an accident, his story a brief and transitory episode in the life of one of the meanest of the planets," we must submit that there is more in such a statement than science warrants. "His very existence is an accident," is not a scientific statement; we do not know of any great step in Nature that has been taken by accident. We may use a word like "episode" if we choose, but whatever be our view of man, it must include the fact that he has given a scientific interpretation of nature and of his place in it.

Naturalism finds the permanent reality of the Universe simply in the world as revealed to us

[1] See R. Otto, "Naturalism and Religion," Trans., London, 1907.

through perception or through the spectacles of Natural Science. But the whole hierarchy of the sciences speaks of another reality which cannot be sense-perceived, and even with scientific spectacles we cannot but be aware of the fundamental mysteriousness of Nature, though we may not therewith be able to discern that "higher nature in nature which makes us men." Naturalism denies any real causality to the personal agent and makes consciousness no more than inactive control. But it is difficult to doubt the genuine conscious activity of the subject. It seems the surest of all scientific facts. Ideas have hands and feet, as Hegel said, and move the world. One may ask, indeed, whether the existence of a material world *per se*—a system of unconscious forces—a self-acting machine—is a thinkable idea at all.

Human Conduct and Animal Behaviour.—In the ordinary man's daily activity we can readily distinguish various grades. There is usually a good deal of habitual routine, the determination of which does not rise to the focus of consciousness at all. Lower than this is some instinctive behaviour, and there are reflex activities often of considerable complexity. On the other hand, the man often passes beyond habitual routine to do something which is positively intelligent. Now and again we must describe his activity as rational conduct. It almost goes without saying that the

greater part of his activity is non-ethical, that is to say, it is not consciously determined in reference to general ideas or ideals, with their attendant feelings as impulses. Some highly moralized men and women are able to give an ethical note to a great part of their daily activity, but this is not the way with most, though at almost any turn a commonplace act may acquire ethical value. By ethical conduct we do not necessarily mean *good* conduct, but conduct deliberately controlled in relation to some ideal—in most cases, doubtless, one that makes for progressive righteousness.

When a man is hungry he usually leaves his work or his play and goes to dine—obedient to an organic signal which sounds in the philosopher as well as in his dog. Instinctively or by force of habit, he neither hurries nor eats more than is customary at the time. Ethically, he may refrain from something which he is fond of, which interferes with his effectiveness as a workman.

Moreover, an action which was ethical to one generation or time of life need not remain so. We live in the hope of this. It was an ethical act on our forefather's part not to overeat himself, and to refrain from killing his enemy, but it costs none of us much ethical effort to avoid gluttony in solids and to abstain from rapid murder. Thus, in a sense, we become happier and better as we become less ethical—as our virtues become more instinctive.

Among animals we find the same inclined plane of activities as in man, with this difference that there is no convincing evidence of ethical conduct. Instinctive activities—which depend on inborn capacities and require neither education or experience for their performance, though they may be improved thereby—often bulk largely; intelligent behaviour, up to the limits of what can be redescribed in terms of perceptual inference—is widespread, but in the strict sense there is no evidence of reason or of morals. Animals may be most loving mates, most careful parents, faithful to their friends, brave to the death for their near kin, but —poor creatures—they are not moral agents. As Nietzsche said, "their virtue is free from any moralic acid." Animal behaviour differs from human conduct for lack of a conceived purpose. Not that animals are automata or wholly instruments in Nature's hand, but their purposefulness is at most perceptual.

It seems, then, that the whole range of activity, which is non-rational and non-ethical, is in a very real sense common ground for man and beast, always allowing that in man's case the activity may be at any moment rationalized or moralized. A day of routine work, performed without definite pleasure or pain, without definite effort or control, but just "gone through with," is often lived by man, but it is hardly human, not to speak

of ethical. Yet we all know of many who can transform their dreary "day's darg" into a discipline of nobility—thus raising it higher than its own poor merits do above the daily activity of that exemplar of our childhood—the busy bee. On the other hand, the bees are perhaps happier, till the winter of their discontent draws near; they may be troubled with parasites, but not with ideals. As Walt Whitman said—so truly—of animals in general—"They do not sweat and whine about their condition; they do not lie awake in the dark and weep for their sins; they do not make me sick discussing their duty—not one is respectable or unhappy in the whole world."

As we study animal life we see a gradual emergence of the fundamental springs of conduct which we find—transmuted of course—in ourselves. Starting with the simple protoplasts, responsive to oxygen, warmth, food, and one another, and also exhibiting in some cases a selective behaviour which we cannot redescribe in physical and chemical terms, we can hypothetically trace the evolution of behaviour. Very important steps were the formation of a "body" of which death was the price, the beginning of bilateral symmetry, the consequent acquisition of head brains, the differentiation of the sexes. From the stages now persistent at different grades of the animal kingdom, we infer that from a primary hunger there arose

that other prime-mover—Love—which almost alone disputes hunger's claims with success. The originally simple attraction between the sexes becomes gradually associated with æsthetic attractions, psychical sympathies, and practical co-operation in work, and fondness is sublimed into Love. This expands till it laps the family in its folds, returns enhanced to the pair, and broadens out again to the kindred. Along another line the primary hunger becomes differentiated into desire to avoid pain, to increase comfort and well-being, to realize the self. As in mankind, the egoistic and altruistic, the self-preserving and other-regarding impulses intertwine, so that at the end they are no more distinguishable than at the beginning.

Has Human Conduct Evolved from Animal Behaviour?—A study of animal behaviour seems to indicate that while we may not be justified in crediting animals with reason or with morals in the strict sense, we must credit them with what may be called the raw materials of morality—with affection, gentleness, and self-sacrifice, with jealousy, vanity, self-assertiveness, and so on through a long list. The fundamental motives are all there.

But in what sense, if any, may it be said that human conduct has evolved from "animal behaviour"? It appears to us that the true answer is, that man inherited from his pre-human an-

cestry what may be called a set of primary impulses, which he immediately proceeded to raise to a higher power by virtue of his peculiarly increased cerebral complexity. What we mean may be illustrated by considering the case of language.

It seems certain that not a few animals have definite words, expressive of particular emotional states or with particular significance of some sort. Even the chick has some half-dozen words and the dog perhaps more, both excelling in vocabulary the infant who has no language but a cry. But no animal is known to have the power of expressing a judgment, however simple, which is the essence of language. It may be, as John Oliver Hobbes says, that "a dog can put more soul into a look than a kind friend can talk in an hour," but we have no warrant for supposing that the dog's sympathy, even when expressed in a welcoming bark, has any general idea behind it.

Now, while we cannot doubt that Man has inherited his brains and the centre of speech and his vocal cords from simpler non-human ancestors, we cannot say that his language was directly evolved from their speech. What was evolved was the Man, with a more complex cerebral structure; and language is a human product. The potentiality of it, the raw materials of it, were prehuman, but so far as we know, language is solely

human. Even if we knew precisely what cerebral differentiations and integrations are conditionally associated with Man's higher powers, even if we could place these in line with a series of progressive changes in animals, we should still have to say—"The Man arose, an organism at length rational; to him all things became new—he spoke, and he was moral." In other words, while we need not despair of finding among animals the *analogues*, the rudiments, the *Anlagen* of language and conscience, we need not hope to discover the phyletic history of these powers by studying animals. Increasing cerebral complexity made a higher intelligence possible, and both language and conscience date from that dawn.

When we consider how it stands with our feelings and those of animals, we find a certain degree of common ground—such as fear of enemies, dislike of pain, sexual passion, jealousy of rival mates, parental affection and the like. On a second plane are those feelings which though shared with animals are peculiarly modified in the case of Man, through association with ideas rather than sense-experiences. On a third plane are those feelings of which Man seems to be sole possessor, such as modesty, remorse, reverence, and religious emotion. The "moral feelings" closely associated with our ethical judgments and entering into the composition of what we call conscience, such as

"shame for evil done," remorse for injury inflicted, "pleasure in good as such," are unique in man, with only dim analogues in the beast, and hardly recognizable buds in the young child.

The two opposed errors which we have to avoid are, too absolute separation, and too complete identification. In regard to the first it is obvious that we cannot prove that any given emotion in the dog is closely akin to one in man; there is no secretion to be analyzed, and the expressions in gesture and physiognomy, though very valuable indices of what is passing within, afford insufficient basis for identification. Notwithstanding, our faith in the unity of nature leads us to suppose two apparently similar emotions in man and beast to be in general nature alike except where there is good reason to believe them different, *e. g.*, when the human form of the feeling in question has obviously been influenced by general ideas. It is easy to see some difference between the jealousy of a stag and the jealousy of a man; but it is equally easy to see differences between the jealousy of two men. One man's jealousy is comforted by a £50 note, another's is cruel as the grave.

On the other hand, we have to avoid the error of hasty identification. By experience, definitized in some sort of social convention, rooks recognize the eighth commandment in the rookery; perhaps men began to recognize it in a similar way. But

as things are, rooks obey the convention by a necessity of a somewhat lower order than that which moves the virtuous man, who is moved by a thought of racial and social consequences, or by a conception of what is fit for conduct universal. In man's case, moreover, the matter is complicated theoretically—though simplified practically—by the high development of what might be called the external conscience, embodied in social traditions, institutions, and laws. In short, just as we find in animals perceptual inferences but not conceptual inferences, so we find no feelings born of general ideas. Animals may be kind, gentle, devoted, and rich in good feelings, but they have no moral feelings or conscience.

At the same time, one cannot doubt that animals have the power of controlling present conduct in reference to an end more or less distant. Apart from the habitual inhibitory powers of trained animals, there are many such cases; thus it is difficult to believe that beavers, who cut a canal across an island or across the bend of a river, have not a perception of the end to be gained. The labor hardly justifies itself until the work is done. But at the most this is a concrete ideal. It would be an error, however, to exaggerate this distinction as if it were quite absolute. It seems more likely that intelligence and reason, the powers of perception and conception, will merge, for just as

species are only arcs of curves, marked off for our convenience, so is it with many other distinctions equally legitimate and useful.

In the history of the cosmos, the emergence of the first living animals marked a new era. There was a new synthesis of matter and energy, the secret of which is hidden.

In the history of animals the establishment of a centralized nervous system and the associated beginning of a unified experience marked another new era.

Similarly, the origin of Man implied a new series of differentiations and integrations of which we get some hint from a study of the child. With Man all things became new.

Thus it seems that to look for morals in the beast is like looking for a backbone in a worm. What we may look for is an *Anlage*, a primordium, a rudiment of that tissue, so to speak, from which reason, conscience, and language, and other distinctively human qualities had their origin. But the real crossing of the Rubicon was due to cerebral mutation. In so saying, it must be remembered that no scientific formula-word lessens the magnitude of the step which was taken. We agree with the philosopher who says that "the breach between ethical man and pre-human nature constitutes, without exception, the most important fact which the universe has to show."

Huxley's Thesis as Regards Human and Cosmic Evolution.—We must now return to the argument expounded by Huxley in his "Romanes Lecture on Evolution and Ethics." The argument was that the mechanism of organic evolution is natural selection in an inexorable struggle for existence, in which there is nothing but ruthless self-assertion, a treading down of rivals, a gladiatorial show, more or less enduring suffering, and the result of which is merely the survival of the most suitable, not of the best in any sense. If this be so, then "the practice of that which is ethically best—what we call goodness or virtue—involves a course of conduct which, in all respects, is opposed to that which leads to success in the cosmic struggle for existence." "Social progress means the checking of the cosmic process at every step, and the substitution for it of the ethical process, the end of which is not the survival of the fittest, but the survival of those ethically the best." Man must pit his microcosm against the macrocosm, and he must not be discouraged. "Man alone," as Goethe said, "can achieve the impossible." The dwarf by his intelligence can bend the Titan to his will in matters practical, so may it be in the domain of morals. "The intelligence which has converted the brother of the wolf into the faithful guardian of the flock ought to be able to do something toward curbing the instincts of savagery in civilized men." But,

"let us understand, once for all, that the ethical progress of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it." "The practice of that which is ethically best—what we call goodness or virtue—involves a course of conduct, which, in all respects, is opposed to that which leads to success in the cosmic struggle for existence." Nature has many voices, but Huxley could hear no helpful word for man in his endeavor after better-being. Similarly, so far as we understand, Professor James, of Harvard, in his lecture, "Is Life Worth Living?" also gives Nature up, finding no "universe," but a "multiverse"; "all plasticity and indifference," a "harlot" and "mere weather."

In Huxley's thesis we recognize several truths, but not the whole truth. It is useful inasmuch as it emphasizes the difference between man and pre-human nature, between the ζῷον λογικὸν πολιτικὸν φιλάλληλον (the rational, social, and altruistic organism of the Stoics) and the rest of creation. It is useful, since it hints at the fact that we cannot find any ethical conduct in the strict sense in even the most loving of animals, though it perhaps exaggerates this difference. It is useful inasmuch as it presses home the truth that man as a personal agent *has* emerged from the drastic rule of Natural Selection; he is Nature's rebellious child and must continue to rebel if he is to continue to hold

his own, still more if he is to make progress. It is useful inasmuch as it emphasizes the fact that ethical progress must always be a struggle, an endeavor, a fight as St. Paul said. On the other hand, we would dissent from Huxley's reasoning on the following grounds:

(1) Huxley does not appear to us to have given a just picture of the cosmic process. He used far too much red. Is it not the case that, while the logic of organic evolution always remains the same, the significance of the process changes when we observe that the milk of animal kindness is selected as well as teeth and claws, that maternal care is selected as well as paternal belligerence, that the world is not merely the battlefield of the strong, but the home of the loving? According to Huxley, life has been and is a continual free fight, and beyond the limited and temporary relations of the family, the Hobbesian war of each against all has been and is the normal state of existence. But, as Kropotkin observes, this has as little claim to be taken as a scientific deduction as the opposite view of Rousseau, who saw in nature nothing but love, peace, and harmony (disturbed by the accession of man).

Almost every critic has pointed out that Huxley could not himself adhere to his gladiatorial show picture. Somewhat contradictorily and somewhat grudgingly he added in the appendix a note

to the following effect: "Of course, strictly speaking, social life and the ethical process in virtue of which it advances toward perfection, are part and parcel of the general process of Evolution, just as the gregarious habit of innumerable plants and animals, which has been of much service to them, is." "Among birds and mammals, societies are formed, of which the bond in many cases seems to be purely psychological; that is to say, it appears to depend upon the liking of the individuals for one another's company. The tendency of individuals to over-self-assertion is kept down by fighting. Even in these rudimentary forms of society, love and fear come into play, and enforce a greater or less renunciation of self-will. To this extent the general cosmic process begins to be checked by a rudimentary ethical process, which is, strictly speaking, part of the former, just as the "governor" in a steam engine is part of the mechanism of the engine."

It may be pointed out that the sentence, "The tendency of individuals to over-self-assertion is kept down by fighting," is, for many cases, a quite unverifiable statement, but let that pass. It is more to the point to notice that to admit a rudimentary ethical process to a rôle like that of the "governor" is admitting much; in fact, it rather takes the edge off his previous argument. But in spite of his appendix, Huxley leaves the reader

with the impression that the self-assertion of the strong at the expense of the weak is the universal law of nature.

(2) Moreover, while it is quite true that the cosmic process leads to the survival of the fittest for given conditions, not necessarily to the survival of the noblest or the most beautiful or, in any way but one, the best; that the parasite is the result of selection just as much as the paragon of creation; that if the northern hemisphere became glacial again, the fittest creatures would be lichens and snow plants; does not Huxley's argument tend to obscure the fact that, after all, there has been a progressive evolution of finer and freer types in the course of the ages? The cosmic process may have "no sort of relation to moral ends," but it has led up to most marvellous masterpieces, along any line you choose to follow, and notably along that line which leads to man. Has it "no sort of relation to moral ends,"[1] when it has led up along many lines to extraordinary exhibitions of parental sacrifice and altruistic devotion? Has it "no sort of relation to moral ends," if it puts a premium on health, vigor, self-control, temperance?

(3) Speaking of the more or less sound argu-

[1] It seems rather strange that Huxley in disclaiming any ethical note in organic evolution should have persistently used phrases like "ruthless self-assertion," or "the unfathomable injustice of the nature of things."

ments in favor of the theory that the moral sentiments have arisen in the same way as other natural phenomena, by a process of evolution, Huxley said, "but as immoral sentiments have no less been evolved, there is, so far, as much natural sanction for the one as the other. The thief and the murderer follow nature just as much as the philanthropist." "Cosmic evolution may teach us how the good and evil tendencies of man may have come about; but, in itself, it is incompetent to furnish any better reason,[1] why what we call good is preferable to what we call evil, than we had before."

Is this really so? On the contrary, it seems that

[1] It is difficult to understand what Huxley meant by "*better* reason." We must first ask whether the study of cosmic evolution furnishes *any* reason why well-doing is preferable to ill-doing. It is not to be expected that it will furnish any more convincing reason than the study of human history furnishes. Without raising any deep questions we may surely agree that good conduct in man is that which, on the whole, makes for evolution—for progress along the line indicated by the ascent of man, that it makes for health, clear minds, fulness and freedom of life, a happier and more harmonious society, and so on. It is thus in a line with that kind of doing which among animals has persisted, and is the opposite of that kind of doing which, as it crops up in Protean guise, is subjected to elimination, or, in the case of parasites, to degradation, to a loss, for instance, of the nervous and muscular activities which make life most worth living. As already explained, it seems to us futile to look among animals for any ethical conduct in the strict sense.

the naturalists are right who point out that what we may call "crime" does not flourish in Nature, except in a few rare cases such as that of the cuckoo; that it is the law of the forest that certain conventions of mutual regard be observed (during hunting at least even the wolves of the pack must forget their private quarrels); and that the reward of great success attends those creatures that excel in sociality, such as the ants and the bees, the rooks and the cranes, the beavers and the monkeys. That man has almost exterminated the beaver does not affect this argument.

Besides, we should remember that what corresponds to virtue in Man is in great measure necessarily represented simply by vigor among animals, and that here Nature's verdict is clear. Disease is very rare unless man interferes. To say that well-doing has only as much natural sanction as ill-doing seems like saying that disease has as much natural sanction as health. On the contrary, it has so little that in extra-human conditions[1] diseased organisms are in most cases rapidly eliminated. Nature's verdict is quite clear.

(4) In general terms, Nature's method of or-

[1] Professor Ray Lankester points out that almost the only case of a persistent microbic disease among animals in a state of nature is that of the phosphorescent sand-hoppers on the French coast; and perhaps even this is due to some human interference with their environment.

ganic evolution is the elimination of unfit variations, the selection of fit variations, and this as a formula remains for us—perhaps the greatest lesson that Nature teaches. As we have seen, the modes of selection differ widely, though the logic of the process is always the same. We submit, therefore, that in social progress we have not to combat Nature's method, but to follow it, and that we do so every time that we favor the virtuous and thwart the vicious, every time that we reject an ugly product and choose a beautiful one, every time that we vote against militarism and make for peace. It is our prerogative to select those forms of struggle which seem most likely to favor the survival of our human ideals.

(5) Finally, another consideration may be suggested. Is it not generally admitted that the moral ideal is one of self-realization through social service, a self-realization which implies a willingness to be immersed and even lost in the good of the whole? And is this not also the deeper aspect of Nature's strategy, that the individual organism realizes itself in its interrelations, and has to submit to being lost that the larger welfare of the whole may be served? To sum up, our general conclusion may be stated thus: "We see that it is possible to interpret the ideals of ethical progress—through love and sociality, coöperation and sacrifice—not as mere utopias contradicted

by experience, but as the highest expressions of the central evolutionary process of the natural world. As evolutionary biologists we are thus practically with moralist and theologian, even with poet and sentimentalist, if you will, against the 'vulgar economist' of Ruskin, or the self-styled 'practical politician' of to-day."[1]

Retrospect.—So far, we have considered man as an organism, the long result of time, the predestined outcome of a long-drawn-out orderly process, the heir of all the ages. We see him emerging, to use Walt Whitman's quaint phrase, "stuccoed all over with quadrupeds."

We then saw, however, that man, because he is man, has freed himself from passive subordination to the cosmic mechanism—in a much greater degree than any other creature. He will not be tied to his mother's apron strings, though he often returns to her wearied. He will make a kingdom for himself—an *imperium in imperio;* he pits himself against the cosmic processes.

We have thus simply hinted at another chapter—how man actively uses Nature for his own advancement, for fuller self-realization, for the development of his spirit. The servant becomes a master, the searcher an interpreter, and the product of evolution furnishes a key to the whole.

[1] Thomson and Geddes, in "Ideals of Science and Faith," London, 1905, p. 73.

Value of the Evolutionary Conception of Man.—In accordance with the philosophical temper of the time, we must now ask what the evolutionary interpretation of man is good for. What is the value of the view that science takes of man's place in Nature? Nietzsche said that history has three great uses—a *monumental* use, perpetuating the memory of great deeds and great men; an *antiquarian* use, showing the living hand of the past in the present; and a *critical* use, enabling us to estimate the present provisional order of things by comparing it with what has been before. So the evolution-doctrine has a monumental use, reminding us of great events in the past; an antiquarian use, showing the solidarity of what is and what has been; and a critical use, enabling us to judge of the present trend of things in the light of past history.

In the first place, is it not of great significance that, while science does not pretend to deal at all with ultimate realities or with the purpose of evolution, it can give a provisional intelligible history of things and living creatures and man himself—intelligible in the sense that it is a genetic description of what has occurred. This, it seems to us, is the greatest contribution which science makes to human thought. As Professor Pringle-Pattison says: "The postulate which underlies every scientific induction is the intelligibility of the uni-

verse—the belief, in other words, that we are living in a cosmos, not a chaos, the belief that the Power at work in the Universe will not put us to permanent intellectual confusion. This is an ultimate trust, which is not capable of demonstration, though *progressively verified and justified by every step we take in the intellectual conquest of the world.*"

Again, looking at the Evolution-idea quite generally as the largest contribution which Natural Science has made to human thought, may we not argue to some purpose in this fashion? Science looks backward to a beginning, and says there is nothing in the end which is not also in the beginning. Philosophy looks forward to an end which illustrates the significance of the whole. Science uses the amœba in its interpretation of man, philosophy uses man in its interpretation of the amœba. There are doubtless difficulties in both interpretations; we have seen that the scientific one is far from easy. But they are not opposed to one another and they seem equally natural to all of us, though we may not be expert in following up either of them. We cannot mix them up together, but neither can we hold them in insulation in our thinking. They are complementary outlooks on the world.

The embryologist describes the development of an individual bird, he uses the fertilized egg-cell as his starting-point, he believes that this in some

way contains the potentiality of all that is to follow—intelligent behavior included, always admitting, of course, that the organism, as it develops, trades with its legacy of talents, using time to gather into itself the influences of environmental nurture. In his science the biologist tries to take the developing egg just for what it seems to him to be—a growing mass of protoplasmic units—self-differentiating, self-regulating, autonomous. He does not use the intelligence of the adult as a factor in embryonic development, for he can describe the sequences without using psychological terms, and he must keep to that method. Yet, for the life of him, he cannot forget that the egg becomes an intelligent creature, and in his whole thought of the egg he must see it in relation to its end.

Similarly, the evolutionist describes the history of the race of birds, using a reptilian stock, and long before that a Protist stock as his starting-point. He believes that his beginning in some way includes the potentiality of all that follows, but in his method he tries to take each stage just for what it seems to him to be. He cannot credit the Protists with a central nervous system, though he believes that they have the remote potentiality of it. Yet, for the life of him, he cannot forget that the original Protists must have had in them the promise and potency of all that follows, always remembering that each stage gathers the results of

time into itself. In his whole thought of the evolution, he must see it in relation to the end. In short, in philosophical language, "If the lower carries in it the promise and potency of the higher, then how can we substantiate the lower as out of relation to the higher in which we read the meaning of the whole development?" (A. S. Pringle-Pattison.)

Inheritance.—Let us think for a moment of the fundamental fact of inheritance.[1] As Huxley says:[2]

> "Every one of us bears upon him obvious marks of his parentage, perhaps of remoter relationships. More particularly, the sum of tendencies to act in a certain way, which we call 'character,' is often to be traced through a long series of progenitors and collaterals. So we may justly say that this 'character'—this moral and intellectual essence of a man—does veritably pass over from one fleshly tabernacle to another and does really transmigrate from generation to generation. In the new-born infant, the character of the stock lies latent and the Ego is little more than a bundle of potentialities. But, very early, these become actualities; from childhood to age they manifest themselves in dullness or brightness, weakness or strength, viciousness or uprightness; and with each feature modified by confluence with another character, if by nothing else, the character passes on to its incarnation in new bodies."

Now let us extend this conception a little. From

[1] See J. Arthur Thomson, "Heredity," Murray, London, 1908.

[2] "Evolution and Ethics," p. 14.

the scientific outlook man is seen as the child of nature. He is the "last inheritor and the last result" of a pedigree which goes back for millions of years, the last manifestation of a Karma which has been gradually modified since the time when life appeared upon the earth. More immediately the paragon of animals is a scion of a Simian stock. Thus, perhaps, we can better understand the beast in the man. Much of the inherent sinfulness which vexes the righteous soul, is the outcrop—the recrudescence—of ancestral habits. We need no elaborate theory of it. We have to let the ape and tiger die, and they often die hard. We rise on stepping-stones of our dead selves to higher things, but the grave clothes hang about us, as about Lazarus, hampering our steps.

Huxley goes on to say:

"After the manner of successful persons, civilized man would gladly kick down the ladder by which he has climbed. He would be only too pleased to see 'the ape and tiger die.' But they decline to suit his convenience; and the unwelcome intrusion of these boon companions of his hot youth into the ranged existence of civilized life adds pains and griefs, innumerable and immeasurably great, to those which the cosmic process necessarily brings on the mere animal. In fact, civilized man brands all these ape and tiger promptings with the name of sins; he punishes many of the acts which flow from them as crimes; and, in extreme cases, he does his best to put an end to the survival of the fittest of former days by axe and rope."

"Return to Nature."—Another corollary drives home a consideration which often seems so impracticable that we wriggle away from it. It is the value of "a return to nature" in one sense of that much-abused phrase. Biologists are familiar with the fact that, if an inheritance is to find appropriate expression, the organism must develop in an appropriate environment. Otherwise, potentialities will not be realized, the legacy cannot be cashed. Now, if our natural inheritance has been determined in the distant past under conditions that imply close contact with nature—emotional as well as practical—it seems common sense that we and our children will always be handicapped unless we can renew the contact. This is part of the true inwardness of the "Nature-study" movement, the *rus in urbe*, and the garden-city. This is, in part, the gospel according to Wordsworth, and according to Thoreau.

There is, however, another side to this. There were conditions of life in ancient days which mankind can never seriously wish to know again. A struggle around the platter of bare subsistence, as of pigs around the feeding-trough, should be an impossible phenomenon among men. Yet, through our selfishness and folly, we often sink back into vital conditions which are horrible anachronisms, which are inhuman and brutal, and then we wonder at a recrudescence of hooliganism, licen-

tiousness, and savagery. There is no cause for wonder. By restoring the undesirable stimuli we have reawakened the beast in the man, the ape once more gibbers folly and the tiger whets his teeth. We have given new life to the latent germs of brutality, which, otherwise, would gradually die away.

The Yoke of Natural Selection.—A third corollary is not less important. There is one sense, at least, in which we can never "return to nature," unless we cease to be human. We can never resume the yoke of natural selection which even early man began to wriggle out of, which man has been more and more effectively throwing off as the ages have passed. Professor Ray Lankester has put this point with splendid clearness.:

"The mental qualities which have developed in Man, though traceable in a vague and rudimentary condition in some of his animal associates, are of such an unprecedented power and so far dominate everything else in his activities as a living organism, that they have to a very large extent, if not entirely, cut him off from the general operation of that process of Natural Selection and survival of the fittest which up to their appearance has been the law of the living world. They justify the view that man forms a new departure in the gradual unfolding of Nature's predestined scheme. Knowledge, reason, self-consciousness, will, are the attributes of Man.

"Nature's inexorable discipline of death to those who do not rise to her standard—survival and parentage for those alone who do—has been from the earliest times more

and more definitely resisted by the will of Man. If we may, for the purpose of analysis, as it were, extract man from the rest of Nature of which he is truly a product and part, then we may say that Man is Nature's rebel. Where Nature says 'Die!' Man says 'I will live.'

"Civilized man has proceeded so far in his interference with extra-human nature, has produced for himself and the living organisms associated with him such a special state of things by his rebellion against natural selection, and his defiance of Nature's pre-human dispositions, that he must either go on and acquire firmer control of the conditions, or perish miserably by the vengeance certain to fall on the half-hearted meddler in great affairs. We may indeed compare civilized man to a successful rebel against Nature, who by every step forward renders himself liable to greater and greater penalties, and so cannot afford to pause or fail in one single step. . . . Man, whilst emancipating himself from the destructive methods of natural selection, has accumulated a new series of dangers and difficulties with which he must incessantly contend."

The Hopefulness of the Evolutionist Outlook.—In general, it seems to us that the evolutionary view is one that inspires and encourages. It is an ascent, not a descent, that is behind us, and there are no limits to set to our advance. Perhaps, indeed, we shall advance more quickly as we become more vividly conscious that our fates are in our own hands. We are no longer as those who look back to a Paradise in which man fell; we are rather as those "who rowing hard against the stream, see distant gates of Eden gleam and do not dream it is

a dream." We have spoken of our heritage from pre-human ancestry whose recrudescence in evil passions sometimes amazes and perplexes even the godly; but we must remember the other side, that we have a heritage of good impulses *which are much older than our race;* the springs of good conduct—of kin-sympathy, of family affection, of gentleness—which have been welling forth almost since life began.

Riddles of the Universe.—We cannot look back on the story we have outlined without a sense of the riddles of the universe.

Even when we keep to things as they are, we find ourselves surrounded by unsolved problems. We see the swallows flying south across the river; how much patient inquiry has there been over this problem of migration; how far are we from a clear understanding of it! This may serve as an instance of the kind of problem that fascinates the naturalist, which he hopes some day to solve.

We move our arm to turn a page, and we pause to reflect upon all that this involves. With some pains we could perhaps give a long account of the motor impulses, muscular movements, chemical explosions, and what not that have occurred; but how far are we from having a clear view of the whole chain of events. We know much, for instance, in regard to the electrical change associated with the muscular contraction, but how little we

understand as to its precise significance. How far we are from understanding what turning the page really means.

It is part of the scientific business to describe happenings in the simplest terms, to connect particular results with particular conditions, to make formulæ which sum up often repeated chains of sequence—how much of this there is still to do in every department of inquiry. Many of the unsolved problems of things as they are will doubtless be cleared up if science goes on developing, and will be then replaced by other unsolved problems. So it will go on—perhaps asymptotically. But even supposing all problems of this sort were cleared up, we should not have explained the world. Why not? Because the terms used are not self-explanatory.

There are many different forms of energy in the world,—powers of changing the state of motion or of doing work. Science measures these different "energies," studies their transferences and transformations, and demonstrates their indestructibility, or, at any rate, our inability to increase or decrease their amount by the slightest. What energy ultimately is, science does not pretend to tell us.

There are many different kinds of matter in the world occupying space and possessing weight. Science studies the properties of the different kinds

of matter, and forms theories of the constitution of matter, *e. g.*, that it consists of molecules which consist of atoms, which consist of corpuscles surrounded by positive electricity, which are themselves units of negative electricity. We know that we cannot add to or take from the sum-total of matter in the world. As far as we are concerned it is quite indestructible. What matter ultimately is, science does not pretend to tell us, unless it explains it away altogether in terms of electricity. The "Ding an sich" is not a subject of scientific inquiry.

It has apparently become necessary to postulate besides matter and energy a third something—the ether. This is a hypothetical "medium of extreme tenuity and elasticity diffused throughout all space, the medium for the transmission of radiant energy." What it is, whether matter or non-matter, we do not know; nor, in the strict sense, do we know that it is at all. It is a necessary fiction in the scientific redescription of occurrences, and corresponds to something real.

Riddles of History.—To understand things as they are, we must throw upon them the light of past history. This is a familar dictum, and it is, of course, in a measure true. But we must not forget how far from complete this genetic knowledge is. How far we are from any security as to the history of the solar system, of the earth, of its

plants and animals, or of prehistoric man. Louis Agassiz spoke of the gap between the unicellular Protists and multicellular organisms with "bodies" as "the greatest gulf in organic nature"; how was that gulf bridged? Every zoologist believes —that is the proper word to use—that backboned animals were evolved from backboneless ancestors, but who shall say from what kind of backboneless animal, or by what steps, or under what conditions? Most anthropologists believe that man was, like other organisms, the long result of time, that he sprang from an ape-like stock, but no one knows from which, or where, or when, or how.

Riddles as to Origins.—Greatest of all perhaps are the riddles as to origins. There is always a good deal of difficulty in starting the triumphant chariot of evolution. "Ce n'est que le premier pas qui coûte."

Given the consolidated earth we can account for its sculpturing, but how did the earth begin? Was it from a condensed nebula, how did the nebula begin? Was the nebula a swarm of colliding meteorites, whence came they? Have the different kinds of matter been evolved, what was the raw material? Is matter explained away as "nothing but electricity," had this an origin?

Given living organisms to start with, we can in some measure redescribe the evolution of our

present-day fauna and flora, but whence came living organisms? Did they first arise from the dust of the earth? By what steps did this come about? And if the living arose from the not-living, what was the origin of this marvellous raw material which had the potentiality of livingness in it?

Given simple behaviour and (inferred) simple psychical processes, we can, with much hesitancy and hypothesis at present, sketch out a series of stages leading on to intricate behaviour and intricate mental processes, but what were the conditions antecedent to mind? Is it coextensive with life, or does it mysteriously emerge when a sufficient number of nerve-cells become integrated into a tiny brain? And if the primitive protoplasts from which the biologist starts had in them the potentiality of mind, then how is that rudiment related to the not-living if the protoplasts came from that?

"Let us admit, as scientific men, that of real origin, even of the simplest thing, we know nothing; not even of a pebble."[1]

It is well, surely, that this perennial difficulty as to origins should be frankly faced, even at the risk of misunderstanding on the part of those who, being unaware of what scientific method is, make apologetic capital out of every such admission,

[1] Sir Oliver Lodge, "Ideals of Science and Faith," London, 1905, p. 27.

proclaiming that science has confessed herself bankrupt. Three notes are here necessary.

(*a*) In the first place, these difficulties as to origins are not all on the same plane. The conditions of the origin of birds are unknown, but we cannot doubt that birds sprang from a reptilian stock, and this problem is much more soluble than that of the origin of Vertebrates. The origin of Vertebrates or the origin of multicellular organisms is almost certain to be much less obscure fifty years hence than it is now; but it is possible that the origin of living organisms will be no nearer solution a century hence. The question of the origin of mind is again of a different order, and it may be that the question as we have put it is quite illegitimate. To ask where the first raw material of the Kosmos came from is to ask how the beginning began.

(*b*) In the second place, sound science can begin at any point without necessarily accounting for—*i. e.*, describing the genesis of—its data. There are few biologists who trouble their heads about the origin of living creatures. They take the origin of organisms for granted, and proceed to study the structure and activities, the development and racial history of particular forms. Similarly there is thoroughly sound anthropology and psychology, starting from man and mind as "given."

(*c*) In the third place, while science aims at redescribing in the simplest available terms what has taken place in the past and goes on taking place now, it does not pretend to explain anything.[1] It shows painstakingly that a certain collocation of antecedents will result in a certain collocation of consequents; it can often analyze the sequence of events into a series of simple movements; but except in this sense of reducing to a common denominator, it does not explain anything. Under certain conditions hydrogen and oxygen combine to form water, and some analysis of the probable succession of events is possible, but in the long run the chemist does not tell us how it is that the two gases form water. Not to be too pedantic, there is a sense in which the physicist can explain the path of a projectile or the course of a comet, but it is always in terms, such as gravitation, which are not self-explanatory. In most cases, moreover, he works with symbols, such as molecules, atoms, and corpuscles, which are representative of the unknown real things, so representative of them that

[1] "It is very desirable," Huxley said, "to remember that evolution is not an explanation of the cosmos, but merely a generalized statement of the method and results of that process. And, further, that, if there is any proof that the cosmic process was set agoing by any agent, then that agent will be the creator of it and of all its products, although supernatural intervention may remain strictly excluded from its further course."

prediction is possible, but which are none the less fictions of his own creation. Science tells us that when counters A, B, C move in such and such a way, counters D, E, F move in an equally definite way. But what makes the moves, or how is it exactly that A, B, C lead to D, E, F, what combines the tactics into a strategy, why should there be a strategy at all? Science cannot tell us.

Professor Ray Lankester[1] puts the position clearly.

"The whole order of nature, including living and lifeless matter—from man to gas—is a network of mechanism,[2] the main features and many details of which have been made more or less obvious to the wondering intelligence of mankind by the labor and ingenuity of scientific investigators. But no sane man has ever pretended, since science became a definite body of doctrine, that we know or ever can hope to know or conceive of the possibility of knowing, whence this mechanism has come, why it is there, whither it is going, and what there may or may not be beyond and beside it which our senses are incapable of appreciating. These things are not 'explained' by science, and never can be."

The Death of the Earth.—Another riddle that gives us pause is the suggestion that comes from various

[1] See *Times*, May 17, 1903, and "The Kingdom of Man," 1907, p. 62.

[2] From our point of view mechanism is an inadequate term for the redescription of living creatures, but it may be used in a wide sense to include all arrangements of natural causes.

quarters that this fair earth of ours and all that it contains will some day die, as the moon for instance has died. "For millions of years," Huxley said, "our globe has taken the upward road, yet, sometime, the summit will be reached and the downward route will be commenced." The indestructible matter and energy will doubtless pass into a different expression, but a particular thought will have completed itself.

The Riddle of Suffering.—Another riddle which can never be far from the thoughts of those who are not extraordinarily light-hearted is the riddle of suffering and sorrow and evil.

Let us consider for a little what is called "the cruelty of nature." We probably make the riddle more difficult by our anthropomorphic way of looking at things, exaggerating the pain that animals feel, but there is a large residuum. Some insects may be cut in two without showing any reaction at all, but it requires an optimist to believe that it can be pleasant to be eaten alive. Let us hope that the oysters which often glide—very much alive—down our gullets, like so many "gustatory flashes of summer lightning," are speedily paralyzed. But this aspect of the problem of "cruelty" does not seem to press heavily on the souls of carnivorous mankind.

Concerning "the cruelty of Nature" Alfred Russel Wallace writes: "There is good reason

to believe that the supposed torments and miseries of animals have little real existence—that the amount of actual suffering caused by the struggle for existence is altogether insignificant." . . . "Animals are spared from the pain of anticipating death; violent deaths, if not too prolonged, are painless and easy; neither do those which die of cold or hunger suffer much; the popular idea of the struggle for existence entailing misery and pain on the animal world is the very reverse of the truth." This is cheerful optimism, yet even Darwin, who confessed that he found in the world "too much misery," concludes his chapter on the struggle for Existence with the sentence, "When we reflect on the struggle, we may console ourselves with the full belief that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply."

If we say that it is not so much the cruelty that repels us, but the rank egoism of it all, then we are raising a different problem, which was considered in connection with Huxley's contrast of human and cosmic evolution.

Or if we allow ourselves to think of the wastage of individual life, we raise another problem. "Admirable doubtless," Prof. D. G. Ritchie wrote, "this scheme of salvation for the elect by the dam-

nation of the vast majority, but pray, do not let us hear anything more about its beneficence." There is no end to self-made problems of this sort—made by introducing irrelevant concepts.

In regard to human affairs, without any affectation of callousness, the scientific inquirer is bound to recognize a number of facts.

(*a*) There are what may be called "growing pains," the tax on progress, the troubles incident on new adjustments and new adaptations. "A heavy tax is levied on all forms of success," as Huxley said. In mankind, as in nature, it holds good that

> "Life is not as idle ore,
> But iron dug from central gloom,
> And heated hot with burning fears,
> And dipped in baths of hissing tears
> And battered by the shocks of doom
> To shape and use."

This is surely better than what Nietzsche called "the universal green-grazing happiness of the herd."

(*b*) Secondly, as we have already indicated, a considerable part of human evil is due to our ancestral inheritance, especially to the beast in the man. We can only set against this the still stronger assets of our inheritance, and the means that are at our disposal for improving our inherited nature by nurture in the widest and highest sense.

(*c*) Thirdly, from the biological point of view, a good many of our troubles and disharmonies are due to the fact that we tend to continue habits, *e.g.*, of eating, which are anachronisms, from which we have both organically and socially evolved away. If we persist in wearing an arctic explorer's dress in the Tropics we should not complain of the heat. The problem becomes complicated for man because he has created around himself an intricate social environment which evolves regardless of the individual. Thus there comes about, for instance, a continual clashing of biological and sociological ideals.

(*d*) Fourthly, we must recognize with Huxley that "there is a terrible amount of *needless* suffering amongst us, part of the awfulness of which is that it means piling up pain and sorrow for generations yet unborn." We must not blame the system of things for this; we are ourselves to blame. And of all futile exercises of the human intelligence perhaps that is worst which seeks to find some apologetic interpretation of *needless* suffering. We should never seek to apologize for the preventible, we should seek to prevent it. Better than any philosophical consolation over spilt milk is the invention of an unupsettable pitcher.

The Philosophical and the Scientific Outlook.—Our general position may be made clearer if we try to indicate how the philosophical outlook differs from

that of science. It is the work of science to reduce things to a common denominator or to a simple beginning, such as Matter, Energy, and Ether, or the life of a protoplast. This sort of analysis and genetic description clears up obscurities, affords a basis for action, and is in any case forced upon us by our desire to unravel things, to refund phenomena into their antecedent conditions. But it does not satisfy the human spirit, partly because the common denominator is in itself mysterious, partly because science never tells us why so much should come out of apparently little. It gives an account of the tactics of Nature, but never explains the strategy. It is unsatisfying.

For this reason every one has some philosophy, which is based on his own experience. He feels, for instance, that the surest reality to him is his own personal agency, particularly his moral activity, and he projects this upon Nature, saying that there must be a First Cause, some real power, giving substance to all the metaphorical causes, the secondary or caused causes, that Natural Science deals with. Thus he finds God as the ever-present real power in the world, operating in and through natural laws. He sees in "natural causes only the connections of phenomena established by an ever-active divine will"; he believes in God as "the real agent in Nature and in all natural evolution."

Or again, he feels that "the purpose of his life is the most intimate and fundamental reality of which he has any knowledge," and he projects on Nature this explanatory unifying idea of purpose, believing that the causal reality of which Nature is an expression is also Purpose—a wider and richer Purpose.

Again, amid the ceaseless flux of things, the endless making and unmaking, Werden und Vergehen, Man makes a demand for an end—in itself—"that is, for a fact of such a nature that its existence justifies itself." He cannot find this in extra-human nature; he can find it only in his own spiritual development. There he finds an end in itself worthy of attainment, and he reads this back into nature as the end of existence as such, as "the open secret of the universe." To many "the moral and spiritual life remains unintelligible unless on the supposition that it is in reality the key to the world's meaning, the fact in the light of which all other phenomena must be read." "Man's personal agency—the one perpetual miracle—is nevertheless our sure datum and our only clue to the mystery of existence." (A. Pringle Pattison.)

Limitations of Science.—There have been some who have not hesitated to publish abroad what they regard as a scientific clearing up of the riddles of the universe, leaving their gullible readers with

the impression that everything has been explained. It would be more accurate to say that, as far as science is concerned, nothing has been explained. Of course immediate explanations are continually being given, but they are never more than statements of fact, or accurate descriptions of happenings, or unravellings of an intricate series of sequences into their component more familiar sequences, or comparisons of what seems a novel succession of events with previously well-known successions, or tracing back a development through its phases, or making a general formula which unifies a whole series of occurrences, and so on. These interpretations leave the fundamental mysteriousness of the universe untouched.

Perhaps the greatest service that we can do in this course is simply to emphasize these limitations of science, thus clearing the way for ideal constructions which each of us must make after his own fashion, which will not be true for us unless we make them ourselves. Thus while it may seem at first discouraging to say that "all our physical experience is rounded with mystery," further reflection will show that "this final margin of mystery becomes the light of life." In face of these riddles, we feel that the scientific outlook alone is unsatisfying. Many scientific workers, who can find no resting-place in science alone, agree with

the author of the "Foundations of Belief," when he says:

> "I do not believe that any escape from these perplexities is possible, unless we are prepared to bring to the study of the world the presupposition that it was the work of a rational Being, who made it intelligible, and at the same time made *us*, in however feeble a fashion, able to understand it." (Page 301.)

Anima Animans.—We have tried to indicate what we believe to be the modern scientific position in regard to the genesis of the Earth, Living Creatures, and Man. How, it may be asked, is the idealistic outlook[1] affected? As far as we can understand, not in the slightest.

(1) It is open to the idealist to give a name to the scientific x which lies behind energy, matter, and ether, and to call it Spirit, the Logos, the Absolute, God.

(2) It is legitimate to use the familiar epistemological argument which points out that the scientific categories are mental concepts of our own making. If we interpret nature in terms of our own thoughts, we cannot use scientific formulæ to explain away our thoughts, as by-products of nervous matter. Those who are fond of talking of the bankruptcy of science—we do not know

[1] The philosophical doctrine of idealism "finds the ultimate reality of the universe in mind or spirit, and its end in the perfecting of spiritual life."

why—often begin by pointing out that this bankruptcy is a foregone conclusion because of the debts with which science starts. But to make apologetic capital of this is again to fail to understand what the aim of science is.

(3) It is legitimate, at present at least, to maintain that, when we pass from inanimate to animate nature, we cannot redescribe vital phenomena in terms of mechanical categories. In life there is something new—in any case there is new synthesis of matter and energy with new properties more wonderful than those of radium. Nothing perhaps is gained by postulating a vital principle or a vital force, but the mechanical categories, as at present formulated, do not enable us to read the secret of the organism. If the animate world has emerged from the bosom of the inanimate, then the common denominator of *Matter*, *Energy*, *Ether* must include the potentiality of giving rise in appropriate conditions to what we call life. This invests the common denominator with even more significance than before.

(4) It is legitimate to point out that the most real thing in the world to us is our own conscious experience. In thinking about ourselves, mind is as necessary a postulate as ether is to the physicist. When we pass from ourselves to the behaviour of other living creatures, we cannot leave mind

out, if we are not to give a false simplicity to the facts. We do not in any way understand how the bodily life comes to have this inner aspect which we call conscious experience. Nor do we understand radio-activity. We know that our mind, as far as we know it, is bound up with matter; we know that it cannot give rise to matter; we cannot think of any way in which matter—say, units of negative electricity—could give rise to it. Mind comes into potency under certain conditions. This is true in individual development as well as in racial history. We cannot think of its being interpolated from without into instruments prepared for its reception. This invests the common denominator with even more significance than before. In fact, it merges into the greatest common measure.

We observe the every-day life of, let us say, a clever bird, such as a parrot or a rook. It seems impossible to give an intelligible account of it without crediting the bird with an intelligence as real as our own. Its power of intelligent behaviour is wrapped up with its highly evolved nervous system. We cannot separate the objective and the subjective aspects, or interpret the one in terms of the other. But this mental life of the bird was implicit in the egg just as the nerve elements were. The power of intelligent behaviour becomes patent at a certain stage in development

just as the power of flight does. Thus mind or something analogous to mind may be latent in a material basis which in itself shows no trace of mind. No trace, except indeed this, that it develops after a fashion that we cannot redescribe in terms of the movements of corpuscles. May it not be that mind lies in the egg—not inactive like a sleeping bud—but doing for the egg what the mind does for the body, unifying, regulating, in a sense directing it, not insinuating itself into the sequences of metabolism, but, so to speak, informing them and expressing itself through them? We mean that the regulative principle, the entelechy, which many embryologists find it necessary to postulate in giving a more than merely chronological account of an individual development, is that resident quality of a living organism which in its full expression we call mind. May not the same conception be extended to the amœba? And why stop there? Why not extend it also to the crystal, the jewel, the mineral, the mountain, the meteorites and the nebula—in short, to the Cosmos in general? It may be said, however, that though man materializes an idea when he makes a clever machine, there is no mind in the machine, and may not the bird be a materialized idea in which likewise there is no mind? But it must not be forgotten that the bird is a *creative* machine.

Conclusion.—We have given to these studies, which must in the meantime end, a large title—"The Bible of Nature"—intending to suggest that Nature is a book we can read and ought to read, a book from which we may learn much that concerns our mortal well-being. In fact, as Goethe said, Nature is the only book with a great lesson on every page. It will be evident, however, that we have hardly done more than touch on one aspect of Nature, namely, its history or Genesis. These studies must, therefore, be regarded simply as the first book of the "Bible of Nature." It should be followed up by other books, such as the book of the Law, the book of Psalms, and the book of Wisdom!

After our preliminary outlook of wonder—at Nature's immensity and magnificent abundance of power, her manifoldness, intricacy, and beauty, we considered the history of the earth as a cooling planet, the advent of life, the evolution of animals, and the ascent of Man. It has all been a story of genesis. Have we read this so that to the concept of an order established from everlasting there has been added the concept of progress, and to that the concept of an evolution which suggests purpose? Have we told the story so as to suggest, as one of our foremost investigators has said, that "men of Science seek, in all reverence, to discover the Almighty, the Everlasting. They

claim sympathy and friendship with those who, like themselves, have turned away from the more material struggles of human life, and have set their hearts and minds on the knowledge of the Eternal"?

Have we told the story so as to make plain that to the healthy-minded the world is as full of wonder now as it was in the ancient days when Job marvelled at the coming and going of Mazzaroth and the sons of Arcturus? Have we made it plain that even when physical science succeeds in reducing a whole order of facts to a common denominator, it cannot explain its nature or origin? That even when biological science discerns great chains of sequence, it remains unaware of what life really is; and that even when science, as a whole, traces out for its own purposes a network of mechanism embracing all, "no sane man has ever pretended, since science became a definite body of doctrine, that we know or ever can hope to know or conceive of the possibility of knowing, whence this mechanism has come, why it is there, whither it is going, and what may or may not be beyond and beside it which our senses are incapable of appreciating. These things are not 'explained' by science, and never can be"? These are things of the spirit, and must be spiritually discerned.

If we have succeeded in some measure with our

task, the meaning of our ambitious title will be clear. It was expressed long ago by Sir Thomas Browne in his "Religio Medici":

"Thus there are two books from whence I collect my divinity; besides that written one of God, another of his servant nature, that universal and public manuscript that lies expansed unto the eyes of all, those that never saw him in the one, have discovered him in the other: this was the scripture and theology of the heathens: the natural motion of the sun made them more admire him than its supernatural station did the children of Israel; the ordinary effects of nature wrought more admiration in them than in the other all his miracles; surely the heathens knew better how to joyn and read these mystical letters than we Christians, who cast a more careless eye on these common hieroglyphics, and disdain to suck divinity from the flowers of nature." (Sect. 16.)

Hear, indeed, in Bacon's words the conclusion of the whole matter.

"This I dare affirm in knowledge of Nature, that a little natural philosophy, and the first entrance into it, doth dispose the opinion to atheism, but on the other side, much natural philosophy, and wading deep into it, will bring about men's minds to religion."—(Bacon, "Meditationes Sacræ X.")